BOOK of ABSTRACTS

PARIS, FRANCE / BEFFROI DE MONTROUGE / **JUNE 16-18, 2026**

17th ICSPP

TO PREPARE AND ENDURE
HIGH-INTENSITY CONFLICTS

Table of contents

INTRODUCTION ----------3

Committes----------4

TUESDAY 16TH JUNE

Opening

GCA B. Baratz

MG J-B Meynard

Lecture 1----------5

Karl Friedl

Lunchtime Posters

Thematic Sessions 1 to 3 (13:30 to 15:30)----------6

Thematic 1 : Physical Performance tests and readiness indicators----------6

Thematic 2 : Nutrition and sustained physical performance----------28

Thematic 3 : Psychocognitive readiness for physical performance, resilience, and well being ---47

Thematic Sessions 4 to 6 (15:45 to 17:45) ----------61

Thematic 4 : From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance ----------61

Thematic 5 : Prevention of musculoskeletal injuries ----------74

Thematic 6 : Sleep in High Intensity context ----------99

WEDNESDAY 17TH JUNE

Thematic Sessions 7 to 9 (8:30 to 10:00) ----------115

Thematic 7 : Physical Performance tests and readiness indicators Part II ----------115

Thematic 8 : Impact of physiological states on brain performance ----------134

Thematic 9 : Challenges for female integration in High Intensity Conflicts ----------148

Thematic Sessions 10 to 12 (10:15 to 11:30) ----------159

Thematic 10 : Thermoregulation in hot environments ----------159

Thematic 11 : Heat, Thermal Strain, and Physiological Monitoring : From sensing to prediction and real-time risk mitigation in operational environments ----------169

Thematic 12 : Non- technical skills in high-intensity conflicts + Ethics regarding performance in High-Intensity Conflicts ----------184

Lunchtime Posters

Thematic Sessions 13 to 15 (13:30 to 15:00) ----------189

Thematic 13 : Heatstroke : prevention and management ----------189

Thematic 14 : Use of machine learning model for individual safety in High Intensity Conflicts-201

Thematic 15 : Epidemiology of musculoskeletal injuries in military settings ----------208

Thematic Sessions 16 to 18 (15:15 to 16:15) ----------221

Thematic 16 : Physiology in cold environments Part II ----------221

Thematic 17 : Soldiers in extreme environment (diving + confined spaces) ----------236

Thematic 18 : Aerospace physiology ----------241

Lecture 2 ---------- 250

Jason Lee

THURSDAY 18TH JUNE

Lecture 3 ----------251

Nathalie Pattyn

Thematic Sessions 19 to 21 (9:45 to 11:30) ----------252

Thematic 19 : Physical training for high-intensity conflicts ----------252

Thematic 20 : Nutrition in hot or cold environment ----------270

Thematic 21 : Post-injury rehabilitation and return-to-duty ----------281

Lunchtime Posters

Thematic Sessions 22 to 24 (13:30 to 15:00) ----------298

Thematic 22 : Biomechanics of load carriage and movement ----------298

Thematic 23 : Performance at high altitude ----------316

Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388 ----------324

Thematic Session 25 (15:15 to 16:15) ----------333

Thematic 25 : Physiology in cold environments ----------333

Testimonies from Ukrainian soldiers and round table about physical performance challenges for Ukrainian front soldiers (15:15 to 16:15) ----------344

Closure

Index ----------348

Bienvenue à Paris ! It is a great honor to welcome you to France and to continue this outstanding event, the ICSPP, together with you. Welcome to the 7th International Congress on Soldiers' Physical Performance!

Three years after the London edition, which focused on Future Soldier, we invite you to explore the following theme: To Prepare and Endure High-Intensity Conflicts. Closely linked to the current challenges we all face, this theme highlights the importance of considering the health status and human capabilities—physical, cognitive, and psychological—of military personnel in order to sustain operational effectiveness in combat. Over the next three days, we will share knowledge across a wide range of fields with the objectives of reducing injuries and operational fatigue, optimizing training and recovery, preventing the effects of extreme environments, and integrating new technologies and physiological data collection into military performance management.

The presentation of your research and the discussions that arise from it are invaluable to us all. As in previous editions—held in Jyväskylä in 2005 and 2011, Boston in 2014, Melbourne in 2017, Québec City in 2020, and London in 2023—these three days will showcase new discoveries, advances, and innovations, while also raising new questions and challenges for the future of the disciplines represented throughout this congress.

We are honored to welcome three distinguished figures in the history of the ICSPP as keynote speakers. Dr. Karl E. Friedl, Senior Research Scientist and former U.S. Army Colonel whose career has been dedicated to advancing human performance, resilience, and readiness in military populations. Dr. Jason Lee, director of the Heat Resilience and Performance Centre and co-chairman of the Human Potential Translational Research Programme at the Yong Loo Lin School of Medicine, National University of Singapore. He studies the physiological demands associated with passive and exertional heat stress and how humans adapt to ensure optimum performance and survival.Dr. Nathalie Pattyn, who has a mixed clinical, research and operational background. She has been deployed with Special Forces teams as a medical officer in the Middle East and the Sahel; and on numerous occasions as the sole physician to Antarctica stations.

The ICSPP is also about the pleasure of meeting in person and sharing memorable moments together, particularly during social events such as a reception on the rooftop of the Beffroi de Montrouge and the gala dinner, which we are delighted to host at the École du Val-de-Grâce. We hope that this edition will be just as enjoyable and enriching as the previous ones.

May these three days in the City of Light be memorable for you, both professionally and personally!

MGI Nathalie Koulmann, Pr. Mounir Chennaoui, MCS Alexandra Malgoyre & ASC Allan Amigo
Head of the 7th ICSPP Organizing Committee

Scientific Committee

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Lecture 1

Tusday 16th June

Dr Karl Friedl

Senior Research Scientis for Army Physiology, US Army Research Institute of Environmental Medecine

Dr. Karl E. Friedl is a Senior Research Scientist and former U.S. Army Colonel whose career has been dedicated to advancing human performance, resilience, and readiness in military populations. Over four decades, has helped shape military policy and practice in areas ranging from body composition and nutrition to environmental medicine, stress endocrinology, biomedical technologies and wearable monitoring, and soldier performance optimization. As a leader in international military and civilian research collaborations, Dr. Friedl continues to drive innovation at the intersection of science, health, and operational effectiveness.

What Got Us Here Won't Get Us There: New Priorities for Soldier Performance in an Era of Complexity

From heat, altitude, nutrition, and physical readiness to mental fatigue, cognitive endurance, and digital human twins, Dr. Friedl explores how soldier performance science is entering a new era. This thought-provoking keynote examines the accomplishments that transformed military readiness and the emerging challenges that will define the next generation of human performance research.

– or, a bit more excitement ?!: -

What if the most important limitation on future battlefield performance is not muscle, but cognition? Join internationally recognized military physiologist Dr. Karl Friedl for a visionary look at the future of soldier performance. Blending history, science, operational experience, and emerging technology, this keynote will challenge conventional assumptions and present a compelling roadmap for the next generation of human performance research.

Thematic 1 : Physical Performance tests and readiness indicators

Salle Moebius - MOD : A.Schmidt + S. Foulis

ORAL PRESENTATIONS

Effects of Head Supported Mass (HSM) on Electromyography-derived Measures of Neck Muscle Fatigue During a Static Marksmanship Task

Sequential Machine Learning Model for Predicting Cardiovascular Physical Readiness Test Failure

Casualty Emergency Evacuation as a Predictor of Hormonal and Inflammatory Changes During Military Operations

The Influence of Interindividual Factors on Army Combat Fitness Test Performance

German Competence Center for Functional Fitness as a new core facility of the German armed forces

The Multi-Stage Fitness Test and Chester Step Test Do Not Provide Equivalent Estimates of Maximal Aerobic Fitness in Royal Navy Recruits

Physical Fatigue Impairs Shipboard Firefighting Performance and Strength but Moderate Mental Fatigue Does Not

POSTER PRESENTATIONS

Comparison between soldiers and fitness-matched civilians on sustained attention, neuromuscular fatigue and perceived responses during an exhaustive cognitive-motor dual-task

Occupations of Peak Physical Performance in the U.S. Navy

On a Mission to Attrition? Six-Month Military Deployment Effect on Muscular Endurance and Aerobic Capacity

Next-Gen Pilots for Next-Gen Aircraft – The Human Performance Enhancement and Optimisation Program in the German Air Force

Physical Fitness Test Results of Military Pilots - 20-year follow-up study

Genotype distribution across multidomain performance profiles in tactical athletes: ACTN3 and MCT1 associations

Effects of different uniform configurations on swimming performance and psychophysiological responses in soldiers

Effectiveness of a task-based conditioning program for enhancing military physical readiness : A study with Brazilian Air Force cadets

Effect of Knee and Elbow protection on Physical Performance and Shooting Performance

Delivering Digital Human Performance Readiness at Scale: A Royal Marines Recruitment Use Case

Assessing Nicotine Use Behaviours and Military Readiness: Validity and Reliability of the Military Nicotine Use Questionnaire

The effects of acute respiratory infections on maximal endurance performance – 12-month follow-up

2 km Run Time as a Predictor of Multi-Stage Shuttle Fitness Test Performance in Military Personnel

Laboratory Precision vs. Field Practicality: Agreement Between Bioelectrical Impedance Analysis and Dual-Energy X-Ray Absorptiometry in British Army Personnel

Thematic 1 : Physical Performance tests and readiness indicators

#46728579
Oral Presentation

Effects of Head Supported Mass (HSM) on Electromyography-derived Measures of Neck Muscle Fatigue During a Static Marksmanship Task

BACKGROUND
Increasing battlefield demands have expanded the use of helmet-mounted electronics. Previous research on aviation-type exposures found that increasing head-supported mass (HSM) is correlated to increased injury risk and decreased performance and led to guidance on HSM limits for the aviation community. However, no such criteria have been adopted for dismounted Soldiers. This study aimed to inform these criteria by characterizing the effects of HSM on neck muscle fatigue during a static marksmanship task.

METHODS
15 novice Soldiers completed a static marksmanship task that involved shooting at an E-type silhouette target 25 times in a prone position. The task was performed under five helmet configurations differing in mass and center of gravity (weight moment (WM) relative to atlanto-occipital joint ranging from 0 – 147 N*cm), and repeated for each configuration in both a pre- and post-exercise state following a 1-hour treadmill walking session. Neck muscle activity was recorded using electromyography (EMG) from superficial cervical flexors, posterior cervical extensors, and upper trapezius muscles involved in head and neck posture. The Hilbert-Huang Transform mean frequency (MF), a frequency-based measure used for assessing muscle fatigue, was computed from the EMG data during 0.5s windows between each shot, and the change in MF over the task duration (i.e., slope) was computed. A Wilcoxon signed-rank test was conducted to assess if MF significantly decreased, signifying muscle fatigue, during the marksmanship task, and linear mixed effects (LME) models were used to test the effects of helmet configuration and exercise on MF slope. Separate tests were run for each muscle, with p-values adjusted using the Benjamini-Hochberg method.

RESULTS
There was a decrease in MF from task onset to completion in multiple cervical extensor muscles (Wilcoxon; median MF slope range = -0.014 to -0.024 Hz/s, all padj < 0.02). This decrease aligns with the primary role of these muscles to maintain the head in an extended posture during the task.

Additionally, the highest WM configuration was associated with a greater MF decline in cervical extensors compared to the lowest WM configuration (LME; b range = -0.070 to -0.089 Hz/s, all padj < 0.05). This may suggest a greater rate of fatigue in these muscles during the task with increased HSM. No significant differences were observed pre- vs. post-walking, which may suggest that the treadmill protocol did not selectively fatigue the cervical extensors and that MF changes primarily reflected acute, within-task fatigue rather than global fatigue.

CONCLUSION
This work highlights that greater HSM can significantly increase neck muscle fatigue during a prone marksmanship task, which may ultimately affect dismounted Soldier survivability and lethality. Future efforts seek to characterize the impact of these effects on operational task performance to inform the mass property design and requirements of headborne systems.

MILITARY IMPACT
The effects of HSM on dismounted Soldier fatigue and performance are not well understood, despite growing demands for increased HSM in high intensity conflicts. This study provides insight on the physiological effects of HSM, highlighting links between HSM and neck muscle fatigue during an operationally-relevant task. Future studies that link changes in fatigue to operational performance will be critical to translate research insights into actionable HSM design criteria for military helmets.

AUTHORS
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Thematic 1 : Physical Performance tests and readiness indicators

#46513335
Oral Presentation

Sequential Machine Learning Model for Predicting Cardiovascular Physical Readiness Test Failure

BACKGROUND
U.S. Navy personnel regularly undergo Physical Readiness Tests (PRTs) to assess cardiovascular fitness and overall physical readiness. Failure on the cardio PRT affects operational effectiveness, potentially resulting in discharge. While prior research has examined predictors of physical fitness, the use of advanced sequential modeling techniques to analyze longitudinal PRT data, predict cardio PRT failure, and identify key features remain underexplored.

METHODS
Active duty Navy personnel with ≥2 PRTs (2014-2020) were included. The analytical cohort included individuals who failed at least one cardio PRT that was not their first recorded test. These individuals were matched on sex, age at PRT, time of PRT within 3 months, and unit to create an equal-sized comparison cohort. A recurrent neural network, gated recurrent unit (GRU), was trained on all available sequences of PRT data for each individual in the cohorts. Model performance was evaluated with AUC and F1 scores. SHapley Additive exPlanations (SHAP) analysis was conducted to assess feature importance, with features analyzed both individually and across grouped domains (e.g., core, cardio, waiver).

RESULTS
The study analyzed data from 56,862 individuals, of whom 28,431 failed the cardio PRT. The GRU-based model demonstrated strong predictive performance (AUC 0.87, F1 score 0.80) on 112 features. SHAP analysis identified prior cardio-related data as the largest domain contributor to the predictive signal, accounting for 32.7% of the importance. This included features such as PRT cardio scores, the cardio machine used, and the cardio modality selected (e.g., run or bike). Among individual features, the top five contributors to the predictive signal were days between PRTs (total feature importance of 14.7%), absent waiver status (9.4%), prior upper body score of “good medium” (5.8%), prior cardio score of “satisfactory high” (5.7%), and choosing to bike for the cardio section (4.2%).

CONCLUSION
The GRU-based sequential model demonstrated strong predictive performance in identifying individuals at risk of cardio PRT failure. SHAP analysis highlighted the role that prior cardio performance, upper body fitness, and waiver-related features have on predicting cardio failure on the PRT. Future research could explore the integration of additional data sources, such as medical history and prescription data, to further enhance predictive capability and guide targeted interventions.

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Thematic 1 : Physical Performance tests and readiness indicators

#46663117
Oral Presentation

Casualty Emergency Evacuation as a Predictor of Hormonal and Inflammatory Changes During Military Operations

BACKGROUND
Armed forces have started to utilize military task specific tests e.g. casualty evacuation, which has been identified to be a physically demanding task that every soldier should be able to conduct. However, military task specific tests' suitability to assess physiological load under operational stress has been reported limitedly. Thus, this study aimed to examine how a casualty emergency evacuation (CEE) test (Mussalo et al. 2025) together with selected anthropometric and physical fitness measures associates with changes in hormonal and inflammatory responses during a 20-hour military field training (MFT).

METHODS
23 conscripts (17 men, 6 women) volunteered for measurements of anthropometrics, physical fitness and the CEE test. In the 20-hour MFT (days 1 and 2), conscripts wore a combat gear including backpack (32.8±1.3 kg), marched 38.5 km and completed 11 tasks in groups. Heart rate (HR) was measured during MFT. Hormonal and inflammatory status was measured pre MFT (day 0), post MFT (day 3) and recovery (day 7). Cortisol (COR), insulin-like growth factor 1 (IGF-1), testosterone (TES), sex-hormone binding globulin (SHBG), creatine kinase (CK), C-reactive protein (CRP) and interleukin 6 (IL-6) were analyzed from blood samples. Wilcoxon signed rank test and Spearman correlation coefficient were used for statistical analyses. Significance level was set to $p \leq 0.05$ (* $p \leq 0.05$, *** $p \leq 0.001$).

RESULTS
During MFT, mean HR was 117±8 bpm and peak HR 174±10 bpm, while energy expenditure was 5036±842 kcal. After MFT (day 3) IGF-1 (-15 %***) and TES (-13 %*) decreased significantly while CK (+759 %***) and CRP (+305 %***) increased. Compared to pre MFT (day 0), IGF-1 (-11 %***) maintained on a decreased level during recovery (day 7), while other biomarkers reversed to baseline levels. When comparing post MFT (day 3) values to recovery (day 7), it was observed that TES (+19 %*) and SHBG (+13 %***) increased while CK (-88 %***) and CRP (-79 %***) decreased.

The CEE test correlated moderately with the values (day 0; day 3; day 7) of IGF-1 (ns; r=-0.42*; r=-0.40*), TES (r=-0.54*; r=-0.59*; r=-0.55*), CK (r=-0.48*; ns; r=-0.42*) and CRP (r=0.41*; ns; ns). Compared to CEE, 12-min run test correlated more strongly with IGF-1 (r=0.64-0.90*) and lean body mass with TES (r=0.73-0.83***). Lean body mass (r=0.42-0.60*), isometric leg press (r=0.41-0.63*) and anaerobic capacity (r=0.42-0.51*) correlated with CK with similar magnitude as the CEE test. Features indicating body fat mass (r=0.41-0.62*) correlated with CRP.

CONCLUSION
CEE predicts moderately changes in hormonal (IGF-1, TES) and inflammatory (CK, CRP) values in military operations. Lean body mass, muscular strength, anaerobic and aerobic performance associated partially more strongly with the respective changes in hormonal and inflammatory values than the CEE test. Because the CEE test is strongly associated with lean body mass, muscular strength and anaerobic performance (Mussalo et al. 2025), it could be used together with aerobic fitness tests to predict hormonal and inflammatory changes in soldiers.

MILITARY IMPACT
CEE can be limitedly utilized to assess military personnel's changes in hormonal and inflammatory values indicating operational stress. However, the CEE test together with aerobic fitness test may provide more reliable assessment of soldiers' physiological strain than the CEE test alone. REFERENCES Mussalo et al. 2025. Physical Fitness Determinants of a Military Casualty Evacuation Test. Mil Med.

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Thematic 1 : Physical Performance tests and readiness indicators

#46727593
Oral Presentation

The Influence of Interindividual Factors on Army Combat Fitness Test Performance

BACKGROUND
It is well-understood that interindividual factors impact physical performance. Variations in muscle mass yield differences in strength and power between sexes and performance declines with age. The purpose of this investigation was to evaluate the impact of age and sex on U.S. Army Combat Fitness Test (ACFT) performance. We also evaluated performance relative to sex-neutral scoring standards.

METHODS
This is a retrospective observational study using population-level data. We show the distributions of ACFT performance outcomes using a series of linear regressions with n=1,329,066 individuals (973,474 males and 319,043 females over a range of ages) with post hoc marginal effects and pairwise comparisons to evaluate group differences. We also evaluated the impact of sex-neutral scoring.

RESULTS
Males scored higher than females on all six ACFT events with the largest differences in the standing power throw (male: 2.99±0.00 female: 1.80±0.00 m $p<0.001$), and smallest in the static plank (male: 2.53±0.00 female: 2.28±0.00 min $p<0.001$). However, there was an average of 50.9% overlap in performance distributions between males and females. Age negatively impacted ACFT performance in all events ($p<0.001$), but sex differences were smaller in older individuals. When rescored, 28% of females passed the ACFT at the male standard, however, that increases to 58% when the standing power throw is removed.

CONCLUSION
In absolute terms, males, on average, outperformed females on all six ACFT events but, for all events, there was significant overlap in performance distributions. Age negatively impacted performance in both sexes. These data are consistent with known examples of elite Soldiers and Marines that demonstrate that when presented with a high standard, many individuals (male and female) can meet that standard with proper training. Supported by USAMRDC; author views not official US Army or DoW policy.

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Thematic 1 : Physical Performance tests and readiness indicators

#46745859
Oral Presentation

German Competence Center for Functional Fitness as a new core facility of the German armed forces

BACKGROUND
Modern armed forces face increasingly diverse operational roles, resulting in a heterogeneous and complex set of functional fitness requirements across military personnel. To address this growing complexity and close existing capability gaps, a centralized, scientifically grounded institution was deemed necessary within the German Armed Forces (Bundeswehr).

METHODS
At the University of the Bundeswehr Munich, chairs from the disciplines of sport science, psychology, and educational science were merged into a single interdisciplinary unit in direct collaboration with operational military entities, forming the German Competence Center for Functional Fitness (KoFFi).

RESULTS
The integration of these disciplines resulted in a synergistic, multi-disciplinary network capable of addressing all dimensions of functional fitness. Core activities span research, evaluation of needs and capabilities, consulting, and knowledge transfer. Areas covered include physical and psychological functional fitness, recovery, sleep, nutrition, non-battle injuries, as well as specialized topics such as women's health and immersive learning methods.

CONCLUSION
The KoFFi successfully closes a critical capability gap within the Bundeswehr by providing a centralized hub that advances functional fitness both scientifically and operationally. Its interdisciplinary structure positions it as a national and international reference center for military functional fitness.

MILITARY IMPACT
Sustaining soldier readiness and performance across increasingly diverse operational roles is essential for modern high-intensity conflict scenarios. The KoFFi directly supports this by providing evidence-based, operationally integrated guidance on all facets of functional fitness, from injury prevention and recovery to psychological resilience, thereby enhancing the long-term operational effectiveness and deployability of military personnel.

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Thematic 1 : Physical Performance tests and readiness indicators

#46763788
Oral Presentation

The Multi-Stage Fitness Test and Chester Step Test Do Not Provide Equivalent Estimates of Maximal Aerobic Fitness in Royal Navy Recruits

BACKGROUND
Assessment of aerobic fitness is central to military selection and physical training strategies. Submaximal assessments may offer a lower-risk alternative to more commonly used maximal assessments. However, little is known about their interchangeability with maximal field-based assessments. This study investigated whether estimated maximal aerobic fitness derived from the 20 m Multi-Stage Fitness Test (MSFT) and the Chester Step Test (CST) were equivalent in Royal Navy (RN) recruits, and to assess the practical implications of any disagreement for fitness classification.

METHODS
Paired MSFT- and CST-derived estimates of maximal oxygen uptake ($\dot{V}O_2max$) were analysed using Bland-Altman limits of agreement (LoA). Agreement in fitness classification across low, moderate, and high categories was examined using MSFT as the reference standard. Sensitivity, specificity, and category-specific misclassification rates for CST were calculated. The study was approved by the Ministry of Defence Research Ethics Committee (2252/MODREC/23).

RESULTS
Eighty-four (F = 5) RN recruits (20 ± 3 years; 1.78 ± 0.08 m; 74.9 ± 10.4 kg) volunteered to complete both the MSFT and CST during Phase-2 Naval Training. Data showed the CST (Mean ± SD: 50.61 ± 6.83 ml·kg-1·min-1) to systematically report higher $\dot{V}O_2max$ values relative to MSFT (44.35 ± 4.58 ml·kg-1·min-1), with a mean bias of 6.26 (95% LoA = -6.43 to 18.96) ml·kg-1·min-1. Regarding fitness classification, overall agreement between tests was low, with only 45% of recruits classified into the same fitness category. Using MSFT as the reference, CST demonstrated poor sensitivity across all categories, particularly for moderate fitness. The CST misclassified 53% of recruits categorised as low fitness, 63% of those with moderate fitness, and 48% of those with high levels of fitness.

CONCLUSION
Submaximal tests, such as the CST, offer practical advantages in military training contexts. However, these data suggest estimated aerobic fitness derived from CST and MSFT is not equivalent in Royal Navy recruits. CST systematically reported higher $\dot{V}O_2max$ values and shows wide limits of agreement relative to MSFT, with individual differences of approximately ±12.7 ml·kg-1·min-1. This non-equivalence has important practical consequences, resulting in substantial misclassification across fitness categories. The findings indicate that CST and MSFT should not be used interchangeably for selection, risk stratification, or monitoring of aerobic fitness.

MILITARY IMPACT
Misclassification of an individual's fitness has direct implications on military selection, physical training interventions, and the identification of recruits at an increased risk of injury and/or attrition.

AUTHORS
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Thematic 1 : Physical Performance tests and readiness indicators

#46811005
Oral Presentation

Physical Fatigue Impairs Shipboard Firefighting Performance and Strength but Moderate Mental Fatigue Does Not

BACKGROUND
Shipboard firefighting is a physically demanding military task performed under conditions that may involve pre-existing physical fatigue, heat stress, and cognitive load. Understanding how these stressors independently affect occupational performance is essential for developing evidence-based physical readiness standards for naval personnel. Despite this, limited research has examined the isolated effects of pre-existing physical and mental fatigue on subsequent firefighting performance and neuromuscular function.

METHODS
Across a series of controlled laboratory studies, participants completed a shipboard firefighting simulation comprising stair climbing, hose dragging, nozzle holding, extinguisher carrying, and casualty dragging. Performance was assessed under multiple conditions and in multiple studies: non-fatigued (Fresh), following a 10-minute physical fatigue protocol, following the same protocol with added heat stress (sauna suit wear), and following a cognitive fatigue protocol (45-minute 2-back task). Time-to-completion, heart rate, core temperature estimate, rating of perceived exertion, and subjective mental fatigue were recorded. Post-simulation neuromuscular function was assessed via isometric mid-thigh pull, isometric push-up, countermovement jump, squat jump, and grip strength.

RESULTS
Physical fatigue significantly increased simulation completion time compared to Fresh conditions ($p < 0.001$), with heat stress further elevating heart rate and perceived exertion without further slowing completion time. Post-simulation, isometric mid-thigh pull and push-up peak force were significantly reduced following both Fatigue and Fatigue+Heat conditions compared to Baseline ($p < 0.05$), whereas jump height and grip strength were largely preserved. In contrast, cognitive fatigue induced by the 2-back task significantly increased perceived mental fatigue and effort to concentrate both before and after the simulation, yet did not impair simulation completion time. rational fatigue in high-intensity conflict scenarios.
Physical activity during the simulation appeared to restore alertness, as sleepiness differences were no longer evident post-simulation.

CONCLUSION
Physical fatigue degrades shipboard firefighting performance and reduces post-task maximal isometric strength, while explosive power appears to be resilient to these stressors. Mental fatigue, despite increasing subjective cognitive load, does not appear sufficient to impair the physical performance of firefighting tasks. Physical fatigue poses a greater immediate threat to physical operational readiness than cognitive fatigue in this context.

MILITARY IMPACT
These results have direct implications for naval force readiness. Physical fatigue prior to emergency tasking significantly degrades both physical performance and residual strength capacity, highlighting the need for fatigue management strategies and realistic physical employment standards. The finding that mental fatigue alone does not impair the physical performance of firefighting tasks may inform operational decision-making regarding crew deployment following sustained cognitive duties, such as watch-keeping. Together, these data support the refinement of military physical readiness tests that account for the multifactorial nature of ope

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Thematic 1 : Physical Performance tests and readiness indicators

#1000053
Poster Presentation

Comparison between soldiers and fitness-matched civilians on sustained attention, neuromuscular fatigue and perceived responses during an exhaustive cognitive-motor dual-task

BACKGROUND
Cognitive-motor dual-task (CMDT) is essential in military operations, yet it remains unknown whether soldiers cope with fatigue, important perceived exertion and cognitive degradation differently from fitness-matched civilians. This study compared sustained attention, neuromuscular fatigue and perceived effort during an incremental cycling and cognitive test (ICCT) in soldiers versus fitness-matched civilians.

METHODS
Thirty-two trained participants (13 soldiers) performed the ICCT, consisting of 3-minute CMDT stages with increasing cycling power (starting at 1 W•kg-1, +0.4 W•kg-1 per stage) until task-failure. Sustained attention was assessed with the Mackworth task. Neuromuscular fatigue was measured via isometric knee-extensor maximal voluntary contraction (IMVC) and femoral nerve stimulation (peak twitch, Pt; voluntary activation, VA). Cycling and mental effort were rated using 100-points Borg scale. Data were analysed using repeated-measures analysis of variance and are presented with 95% confidence intervals (CI), and effect sizes (Cohen's d).

RESULTS
Cycling power and heart rate at task-failure were comparable between groups (all P≥0.13). Mackworth performance was similarly impaired at task-failure (P=0.47). IMVC and VA declines throughout the ICCT were comparable between groups (P≥0.25), but Pt decreased more in soldiers than in civilians (mean difference of -19±12%; 95%CI [-30, -9]; d=1.4; P<0.001). Soldiers also reported lower cycling effort (-6±3 a.u.; 95%CI [-12, -1]; d=0.69; P=0.020) and lower mental effort (-13±5 a.u.; 95%CI [-22, -5]; d=0.87; P=0.003).

CONCLUSION
Overall, military position did not confer an advantage in dual-task performance or resistance to central motor command impairments, but was associated with a reduced perception of effort despite greater peripheral fatigue under an exhaustive situation.

MILITARY IMPACT
Military personnel exhibit a distinct capacity to tolerate physical and mental strain, reporting lower perceived exertion despite reaching higher levels of peripheral fatigue. This particular profile constitutes a key asset for sustaining mission performance under exhaustive conditions and designing dedicated training programs.

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Thematic 1 : Physical Performance tests and readiness indicators

#46513504
Poster Presentation

Occupations of Peak Physical Performance in the U.S. Navy

BACKGROUND
The U.S. Navy requires routine Physical Readiness Tests (PRTs) to maintain operational readiness. While PRT scores range from “Failure” to “Outstanding,” consistent high performance, defined as achieving a score of Outstanding or Excellent, is indicative of exceptional physical fitness. No studies have leveraged data from the PRT to examine occupation and physical fitness, which could potentially inform targeted health interventions.

METHODS
Active duty Navy personnel with ≥2 valid PRTs (2014-2020) were included. Navy occupations were grouped by occupational code into 37 categories, as defined by the Defense Manpower Data Center. High PRT performance was defined as the proportion of PRTs scored as Outstanding or Excellent. A generalized linear model (GLM) was used to assess the relationship between Navy occupations and high PRT performance, while controlling for age and sex. Adjusted probabilities were calculated to examine the effect of occupations on performance, with 95% confidence intervals (CIs) reported.

RESULTS
A total of 363,326 individuals were included in the analysis. On average, after adjusting for age and sex in the GLM, individuals were rated Outstanding or Excellent on 32.2% (95% CI: 32.1-32.3%) of their PRTs. The three occupations with the top proportion of high PRT performance were special operations (adjusted probability [AP]: 91.1%, 95% CI: 90.8-91.4%), explosive ordnance disposal/divers (AP: 72.9%, 95% CI: 72.3-73.5%), and air crew (AP: 52.8%, 95% CI: 52.3-53.3%). The three occupations with the lowest proportion of high PRT performance were missile guidance (AP: 18.6%, 95% CI: 18.4-18.9%), sonar equipment (AP: 18.0%, 95% CI: 17.6-18.3%), and other electronic equipment (AP: 17.8%, 95% CI: 17.4-18.2%).

CONCLUSION
These results reveal physically demanding occupations have the highest proportion of high PRT scores. Occupations with the lowest proportion of high performers may face barriers to fitness, such as limited access to facilities and long or irregular work hours. Targeted interventions among those with the lowest proportion could boost Navy force readiness.

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Thematic 1 : Physical Performance tests and readiness indicators

#46645287
Poster Presentation

On a Mission to Attrition? Six-Month Military Deployment Effect on Muscular Endurance and Aerobic Capacity

BACKGROUND
Evidence from long-term combat operations often reports considerable attrition to soldiers' physiques due to irregular schedules, heightened environmental stress, and restricted recovery. However, contemporary peacekeeping and deterrence missions in temperate climates may present different environmental and occupational loads that remain understudied. This study investigated the effects of a six-month noncombat deployment on standard field-based fitness metrics (hand-release push-ups, pull-ups, sit-ups) and aerobic capacity, while distinguishing deployment-specific adaptations from a non-deployed control group.

METHODS
Thirty-six deployed (DG; mean age = 33.9, SD = 8.1 yrs) and eighteen control soldiers (CG; mean age = 32.7, SD = 7.2 yrs) from the same regiment were assessed PRE- and POST-deployment. Deployed soldiers on a noncombat mission were stationed at NATO (eFP) facilities in Lithuania, where training was self-directed and voluntary during off-duty hours and used designated Morale, Welfare and Recreation (MWR) facilities, including strength tents (machines, free weights) and container gyms. The CG performed standard peacetime garrison duties, with unrestricted access to equipped facilities at its home base (Czechia) and regular unit physical training. Muscular endurance was evaluated via the 2-minute hand-release push-ups, pull-ups to failure, and 2-minute sit-ups. Aerobic capacity (VO2peak) was measured using the graded Bruce treadmill protocol. The study was approved by the Institutional Review Board. Statistical significance was set at $p \leq 0.05$.

RESULTS
Using linear mixed-effects models, a discernible Condition × Group interaction was observed for all muscular endurance tests (all ps < 0.005). The DG demonstrated improvements in push-ups (Δ = +9.47 [7.13, 11.81] reps, g = 1.08), pull-ups (Δ = +3.34 [2.35, 4.33] reps, g = 0.63), and sit-ups (Δ = +7.10 [3.84, 10.37] reps, g = 0.60). Conversely, the CG showed no discernible changes in push-ups (Δ = +2.05 [-1.61, 5.71] reps, g = 0.18), pull-ups (Δ = +1.40 [-0.07, 2.87] reps, g = 0.24), or sit-ups (Δ = -2.65 [-7.76, 2.46] reps, g = -0.18). Aerobic capacity (VO2peak) remained unchanged in both groups (DG Δ = +1.18 [-0.37, 2.73] ml/kg/min, g = -0.18; CG Δ = -0.85 [-3.23, 1.53] ml/kg/min, g = 0.16). Mixed-effects modeling revealed low marginal R^2 (0.01–0.23) but high conditional R^2 (0.77–0.92), indicating that individual baseline characteristics and training behaviors, rather than deployment status alone, drove performance trajectories.

CONCLUSION
A six-month deployment in a temperate, noncombat mission with accessible training facilities allows maintenance of aerobic capacity and gains of muscular endurance, rather than causing general detraining. The stability of VO2peak suggests that self-directed training mitigates the endurance declines typically reported in higher-intensity combat theaters. Deployment-related adaptations are highly context-dependent and driven by individual discipline within environmental constraints.

MILITARY IMPACT
Our findings challenge the assumption that physical conditioning inevitably degrades during prolonged missions. Military leadership should prioritize providing individualized training facilities (e.g., strength tents/container gyms) to support autonomous readiness maintenance in the field. When such infrastructure is available, deployment can serve as an opportunity to maintain conditioning. Maintaining VO2peak should be viewed as a successful outcome in mission settings.

AUTHORS

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Thematic 1 : Physical Performance tests and readiness indicators

#46653518
Poster Presentation

Next-Gen Pilots for Next-Gen Aircraft – The Human Performance Enhancement and Optimisation Program in the German Air Force

BACKGROUND
Demands for the pilots of the Next-Gen (fighter) aircraft will shift away from aircraft operation to mission-manager. In order to be able to prevail and excel in current and future operations, pilots need to be fully prepared on the highest level of performance. To achieve this goal, the German Air Force (GAF) has developed the „Human Performance Enhancement (HPE) and Optimization (HPO)-Program for German Armed Forces Aircrews“. The program aims to provide modular and performance-oriented measures and interventions for the individual crewmember, based on operational demands. Special Policy Letters (PL) address several specific points of the program (e.g. Fitness, Nutrition). To assess aircrew-specific physical fitness, GAF has selected a test battery for the HPE/HPO program and as a first step, performance data from elite pilots were obtained to provide an insight into operationally relevant performance levels. Based on the data, a baseline for HPE/HPO interventions could be derived.

METHODS
Commanders of all GAF jet fighter wings and the commander of the Attack Helicopter Regiment 36 were asked to identify their top tier pilots. Pilots could participate voluntarily in the study comprised of the following tests: anthropometric measurements including body fat content by bioimpedance, Basis-Fitness-Test (1000m run, 110m shuttle sprint and fixed arm hang), and the Magglinger Test (dorsal, ventral, lateral trunk strength). Nutritional habits were recorded using an online questionnaire. Testing and data collection was performed in the wings from June to October 2023 by a specifically trained team with the support of the local HPE/HPO-teams. The study was approved by an medical ethics committee and the responsible data protection officer. Every participant was informed oral and written, and gave their written consent prior testing in accordance with the Declaration of Helsinki.

RESULTS
37 male subjects (22 jet, 15 rotary), median age 32.0 years (IQR 9,0 years) participated in the study. Fitness wise, Body-Mass-Index, Waist Circumference, Waist-to-Height-Ratio, ventral, dorsal, and lateral trunk strength showed marked differences to reference values from the German Armed Forces and civilian populations, including top level athletes. Results from the nutritional questionnaire hinted at possible ways for improvement when compared to the recommendations of the German Nutrition Society.

CONCLUSION
Study results were the first step for the definition of operationally relevant reference/baseline values for pilot physical performance parameters. They were incorporated into a PL now governing the GAF-wide implementation of HPO testing procedures. It provides a toolbox which can be complemented with airframe, wing, mission or pilot related testing modules. Based on the results, an additional PL is currently being finalized, covering the area “Nutrition”.

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Thematic 1 :
Physical Performance tests and readiness indicators

#46692197
Poster Presentation

Physical Fitness Test Results of Military Pilots - 20-year follow-up study

BACKGROUND
The increase in overweight and decline in physical fitness of servicemen has become a challenge for the armed forces in Europe. However, there is less studies investigating the changes of physical fitness and body weight during the career among the servicemen and particularly among special operators such as fighter pilots. The aim of this study was to investigate the change of aerobic fitness and body weight among the Finnish Air Force military pilots during their career.

METHODS
Eighty-three voluntary Finnish Air Force pilots participated in the study. Aerobic fitness was evaluated with the bicycle ergometer test where the initial workload of the ergometer test was 20 W, and it was increased by 20 W every minute until exhaustion. The work capacity in the ergometer test was measured both as maximal power in wats and further as average relative power (watts per body mass) of the last cycling minute. The baseline ergometer test was done as a part of the pilot selection. All subjects must have reached the minimum level of 3.5 Wmax/kg in the ergometer test during their selection. The follow-up tests at the age of 30 yrs. (n = 83) and 40 yrs. (n = 71) were executed as a part of the pilots' annual aeromedical examination.

RESULTS
There was no difference in maximal power: 307 (±40) W in baseline, 302 (±35) W in 10- and 294 (±37) W in 20-year follow-up. The average body mass of the pilots in the baseline was 71.3 (6.6) kg, and it increased ($p<0.01$) during the follow-up periods as follows: 78.8 (±7.1) kg and 81.1 (±7.9) kg at the age of 30 and 40 years, respectively. There was a significant ($p<0.01$) change in the body mass increase between the baseline and the 10 and 20 year the follow-ups but, however, no significant change between the 10- and 20-year follow-ups was observed. The average power of bicycle ergometer test was 4.32 (±0.48) Wmax/kg in the baseline test, and it declined to 3.85 (±0.44) and 3.65 (±0.52) Wmax/kg in the 10- and 20-year follow-ups, respectively. The decline was significant ($p>0.05$) between both baseline vs. 10yrs follow-up and 10yrs to 20yrs follow-up.

CONCLUSION
The maximal power did not change during the follow-up. However, this study identifies significant body weight increase among military pilots during their career. Therefore, the decline in aerobic fitness (Wmax/kg) test results relative to body mass is explained with the increase of body weight.

MILITARY IMPACT
Enhancing physical fitness and preventing increase in body weight may represent important preventive strategies to reduce the burden of pilots and keep them in fit to fly.

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Thematic 1 : Physical Performance tests and readiness indicators

#46731778
Poster Presentation

Genotype distribution across multidomain performance profiles in tactical athletes: ACTN3 and MCT1 associations

BACKGROUND
Tactical athletes exhibit multidomain performance profiles. Within units, individuals may meet common standards yet differ substantially in dominant physiological and neuromuscular characteristics. Fitness is therefore better described by continuous profiles rather than discrete “types” or unit affiliation. Genetic variants involved in skeletal muscle structure and metabolic transport have been associated with inter-individual differences in performance. ACTN3 (rs1815739) has been linked to power-related phenotypes, whereas MCT1 (rs1049434) has been associated with variation in lactate kinetics during high-intensity exercise. However, genotype distributions across empirically derived multidomain performance profiles have not yet been examined.

METHODS
236 Swiss Special Operations Forces candidates and operators, from ten Tier 1 and Tier 2 units, completed a standardized test battery. Fitness response variables were grouped into five tactical fitness domains: strength, power, severe-intensity muscular and cardiopulmonary work, aerobic endurance, and visuomotor reaction time. Domain scores were computed from raw variables within each domain. Principal component analysis was applied to the five domain scores. K-means clustering (k = 3) was performed on standardized principal components (PC)1–3 scores to derive multidomain profiles. Gene polymorphisms were assessed by a melting curve analysis versus validated references in polymerase chain reactions on genomic DNA from buccal swabs. Distributions across performance clusters were compared using contingency-table Bayes factors (BF10), quantifying evidence that genotype frequencies differed across clusters.

RESULTS
PC1-PC3 explained 75.4% of total variance. Clustering of standardized PC scores yielded three overlapping profiles with modest cohesion (mean silhouette = 0.27), indicating graded rather than discrete structure. Profiles were characterized as (1) endurance–reaction advantaged, (2) severe-intensity tolerance–oriented, and (3) power–strength dominant, with substantial overlap of unit affiliation. ACTN3 genotype distributions differed strongly across clusters (BF10 = 505). The power–strength dominant profile showed marked over-representation of ACTN3 CC, whereas TT was relatively more frequent in the endurance–reaction profile. MCT1 showed moderate evidence for differential distribution (BF10 = 3.8), reflecting smaller shifts across profiles.

CONCLUSION
Elite tactical units comprise heterogeneous, overlapping multidomain readiness profiles. ACTN3 CC is over-represented in power–strength dominant profiles, with weaker evidence for MCT1 differences. These findings support an association between genetic variation and multidomain performance structure without implying deterministic assignment.

MILITARY IMPACT
Multidomain profiling may support force development by identifying complementary physiological strengths within units. Genetic information should be interpreted cautiously as biological context rather than selection criteria, but may inform individualized conditioning strategies in high-intensity operational environments.

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Thematic 1 : Physical Performance tests and readiness indicators

#46775288
Poster Presentation

Effects of different uniform configurations on swimming performance and psychophysiological responses in soldiers

BACKGROUND

During wet-gap operations, soldiers may experience accidental water immersion while wearing full combat uniform (CU), making swimming and water-survival mission-relevant competencies in contemporary European operating environments. However, empirical data on swimming in CU are limited and annual swim testing often relies on lighter clothing conditions. Therefore, we evaluated swimming performance, psychophysiological responses, technical execution, and trial completion across swimwear (SW), field uniform (FU), and CU to inform assessment and training to enhance safety and mission success.

METHODS

Soldiers (N=57; 24.6% women; not assigned to specialist roles) completed randomized crossover 50 meter swim trials in SW, FU (shirt, jacket, trousers, boots), and CU (FU, helmet, ballistic vest, gloves, weapon replica) in an indoor pool. Heart rate was monitored throughout the trials to derive HRmean and HRpeak (beats per minute (bpm)). Rating of perceived exertion (RPE) was obtained post-trial. Blood lactate (Lac, millimoles per liter (mmol/L) was sampled at rest, post-warm-up, post-trial, at +3, and +5 minutes. Technique-fault counts (TF) were recorded. Between-condition differences were analyzed with mixed-effects models. Associations with CT were examined with Pearson's correlations (anthropometrics, body composition, and psychophysiological responses) and Spearman's rank correlation (TF). Receiver operating characteristic analyses (ROC) tested whether SW and FU CT discriminated CU completers from non-completers. Differences between completers and non-completers were analyzed with t test and Mann Whitney U test ($p \leq 0.05$).

RESULTS

CT increased from SW (52.1 s [47.6–56.6]) to FU (81.5 s [77.1–86.0]) and CU (116.7 s [111.7–121.7]) ($p<0.001$). Likewise, psychophysiological responses progressively increased (all $p<0.001$), with HRpeak reaching 167.7 bpm [161.9–173.4], HRmean 144.7 bpm [139.5–149.9], Lac 11.3 mmol/L [10.6–11.9], and RPE 18.0 [17.4–18.5] in CU. More TF were associated with longer CT (SW: $\rho=0.6$; FU: $\rho=0.7$; CU: $\rho=0.8$; all $p<0.001$). CU non-completion was 26.3%. Completers and non-completers differed in CT (SW: $d=1.8$; FU: $d=1.5$; both $p<0.001$) and TF (SW: $r=0.5$; FU: $r=0.6$; both $p<0.001$). ROC analyses indicated good discrimination (Area under the curve: SW=0.89; FU=0.84; $p<0.001$). Youden-index cut-offs based on CT in SW and FU did not eliminate CU non-completion and sensitivity-maximizing cut-offs classified 73.8% (SW) and 52.4% (FU) of CU completers as non-completers.

CONCLUSION

Added clothing and equipment increased CT and psychophysiological strain, with CU representing a high-intensity effort. Technique degradation and 26.3% CU non-completion indicate that CU swimming is not merely the "same task but harder", but reflects a meaningful shift in task demands. Despite good discrimination, sensitivity-specificity trade-offs limit the utility of SW- and FU-based tests as stand-alone indicators of military-specific swimming competence.

MILITARY IMPACT

For non-specialist soldiers, swimming in CU did not appear viable even over short distances in a controlled pool setting due to high psychophysiological strain and safety risks. CU-specific familiarization, training, and assessment – including post-immersion orientation, procedures to manage or shed equipment, and swimming or floating in clothing – are recommended to prepare soldiers for accidental water immersion during high-intensity conflicts.

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Thematic 1 : Physical Performance tests and readiness indicators

#46785231
Poster Presentation

Effectiveness of a task-based conditioning program for enhancing military physical readiness : A study with Brazilian Air Force cadets

BACKGROUND
The professional demands of military personnel require high levels of readiness to ensure effective societal protection. The Brazilian Air Force (BAF) has developed research to establish essential Combat Tasks (CT) and Simulated Tasks (ST) to predict military performance. Although a physical training methodology based on these specific tasks has been proposed, its effectiveness in improving biomotor capacities and operational performance needs to be tested. This study evaluated the impact of a 10-week task-based conditioning protocol on the physical readiness levels of cadets at the Brazilian Air Force Academy (AFA).

METHODS
The study included a volunteer sample of 18 BAF cadets aged 18 to 25. The 10-week task-based protocol consisted of five sessions of 90 minutes per week, integrated into the daily military physical training routine. The protocol was organized into seven stages, including system analysis, external load determination, and periodization. Assessments included body fat percentage, horizontal jump, reaction time, agility (Shuttle Run), strength (Leg Tuck and Pull-ups), and a 3.2 km loaded march with a 14 kg backpack. Data normality was assessed using the Shapiro-Wilk test. Differences between pre- and post-intervention were analyzed using the Paired t-test for normally distributed variables and the Wilcoxon signed-rank test for non-parametric data, with the significance level set at 0.05.

RESULTS
The 10-week task-based protocol resulted in significant improvements ($p < 0.05$) in most domains. Body fat percentage significantly decreased from 9.8 ± 2.8% to 8.6 ± 2.8% ($p < 0.001$). For neuromuscular capacities, mean horizontal jump distance increased from 198.1 ± 16.6 cm to 207.6 ± 15.9 cm ($p < 0.001$), and Shuttle Run times significantly improved from 11.0 ± 0.7 s to 10.1 ± 0.6 s ($p < 0.001$). Strength markers also improved, with the Leg Tuck average rising from 9.6 ± 6.3 to 11.7 ± 6.5 repetitions ($p = 0.037$).

Regarding tactical performance, 94% of cadets reduced their 3.2 km loaded march time, with a significant mean reduction from 28.12 ± 1.28 min to 26.68 ± 1.33 min ($p < 0.001$). No significant differences were observed for reaction time or pull-ups ($p > 0.05$).

CONCLUSION
The 10-week task-based conditioning program effectively improved body composition, power, agility, and specific strength. The protocol demonstrated efficiency in transferring physical gains to tactical performance, as seen in loaded march efficiency. Findings confirm that training structured around operational tasks is superior for developing specific military physical readiness.

MILITARY IMPACT
This research validates task-based methodology in elevating troop readiness. Implementing this conditioning program across BAF training schools optimizes tactical athlete performance in combat-simulated conditions, directly contributing to the efficiency of national defense missions.

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Thematic 1 : Physical Performance tests and readiness indicators

#46789892
Poster Presentation

Effect of Knee and Elbow protection on Physical Performance and Shooting Performance

BACKGROUND

Appropriate clothing and equipment are essential for military personnel to effectively carry out training and operational tasks. Adequate protection of vulnerable areas such as the knees and elbows is important to reduce injury risk, particularly during activities that involve kneeling, crawling, and rapid changes in posture. However, protective equipment should not compromise mobility or interfere with the ability to assume and maintain stable shooting positions. A stable shooting posture is a key determinant of shooting performance and may be influenced by the type and configuration of equipment worn. Knee and elbow (K&E) protection systems are available in various designs, differing primarily in their fixation to the user. This study evaluated the effects of two fixation strategies on mobility and shooting performance.

METHODS

Sixteen male soldiers (height:179 ± 2 cm; body mass: 79.9 ± 4.8 kg) completed a standardized mobility and shooting protocol under three conditions: (1) Control (standard battle uniform, no protection), (2) K&E 1 (clip-on knee protection, strap-only elbow protection), and (3) K&E 2 (loop-integrated knee and elbow protection). Mobility was assessed using the Load Effects Assessment Program (LEAP) obstacle course, recording total and individual obstacle completion times (s). Immediately afterward, shooting performance (hit probability %) was evaluated with an optical shooting simulator (Noptel, FN expert) simulator in standing, kneeling, and prone positions. Perceived stability in prone and kneeling position, and visual inspection on correct K&E fixation placement afterwards were rated on a subjective scale. Data were analyzed using repeated-measures ANOVA.

RESULTS

No significant effect of knee and elbow (K&E) protection was observed on hit probability scores ($p > 0.05$). Similarly, perceived shooting stability did not differ between conditions ($p > 0.05$). Total LEAP completion time was not significantly affected by clothing configuration (Control: 177.9 ± 10.8 s; K&E 1: 185.3 ± 13.1 s; K&E 2: 182.3 ± 11.2 s; $p > 0.05$). However, analysis of individual obstacles revealed significant slower completion times for the Tunnel & Hatch (K&E 1: Δ1.2 s, $p=0.033$) and Low Crawl (K&E 1: Δ1.5s, $p<0.001$, K&E 2: Δ1.1s, $p=0.014$) obstacles compared to Control. Finally, Elbow protection 1 demonstrated significant lower fixation scores compared to elbow protection 2 (1.5 ± 0.7 vs 2.6 ± 1.1, $p<0.05$).

CONCLUSION

Knee and elbow (K&E) protection did not significantly hinder or improve shooting performance, perceived shooting stability, or overall mobility performance. However, both K&E systems negatively impacted performance on crawling obstacles, even though being designed to support such tasks. Loop-integrated attachment for elbow protection demonstrates better fixation during military critical tasks.

MILITARY IMAPCT

These results inform improvements in protective equipment to enhance safety during prone and crawling tasks while maintaining mobility and reducing injury risk, thereby supporting training and operational readiness. Optimized clothing and equipment that facilitate mobility and shooting performance enable greater preparedness for both training and battlefield conditions.

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Thematic 1 : Physical Performance tests and readiness indicators

#46796271
Poster Presentation

Delivering Digital Human Performance Readiness at Scale: A Royal Marines Recruitment Use Case

BACKGROUND
Royal Marine (RM) candidates must achieve high levels of physical and psychological readiness prior to initial military training, yet preparation support has traditionally relied on fragmented delivery with limited population reach. Digital human performance readiness platforms offer scalable candidate preparation support, but operational evidence of implementation and impact in military recruitment contexts remains limited.

METHODS
A bespoke digital readiness platform ('Commando Ready') was deployed as part of routine service delivery across the 2025 RM recruitment cycle to provide structured physical training guidance, injury prevention education, and behavioural readiness support prior to the Candidate Preparation Course (CPC). Platform deployment was evaluated using system reach and adoption metrics, including downloads, active users, and programme engagement. Retrospective outcome data were obtained for all 2025 RM CPC attendees (n=1722) and matched anonymously via unique registration IDs to verified platform users. Pass rates were compared between users and non-users and further stratified by duration of verified use prior to CPC attendance.

RESULTS
Across the 12-month period, 'Commando Ready' recorded 17,166 downloads, 15,432 active users, and 7,653 structured training programmes initiated, demonstrating substantial reach across the recruitment pipeline. Among candidates with confirmed CPC outcomes (n=1482), verified platform users demonstrated higher pass rates than non-users (53.5% vs 49.5%), corresponding to a 17% increase in odds of pass (OR 1.17, 95% CI 0.95–1.44), although not statistically significant ($\chi^2(1)=2.37$, $p=0.12$). However, CPC pass rates differed when stratified by duration of verified use (non-use: 49.4%, short-term [<3 months]: 62.3%, long-term [>3 months]: 51.5%; $\chi^2(2)=10.4$, $p=0.006$). This short-term use prior to assessment was associated with a ~13% absolute increase in pass rate compared with non-user, whereas longer-term use showed outcomes comparable to non-users.

This pattern suggests that targeted engagement immediately prior to assessment may be more influential than prolonged exposure alone. Further, active users completed an average of ~30 app tasks across multiple performance domains and content types (workouts, videos, articles).

CONCLUSION
Digital readiness delivery within RM recruitment is feasible at scale. While overall differences between users and non-users were modest, short-term engagement prior to assessment was associated with improved CPC outcomes. These findings suggest that timely, targeted digital preparation embedded within recruitment pathways may contribute to maximising personnel inflow and reducing preventable attrition. Operational implementation also highlighted the importance of role-specific design, behavioural engagement features, and RM-aligned content structure in candidate-facing performance systems, with organisational buy-in supporting adoption and routine use.

MILITARY IMPACT
Digitally enabled readiness platforms provide a scalable, resource-efficient mechanism to extend holistic performance support across geographically dispersed candidate populations while generating actionable data to inform force-generation decisions. When aligned to key recruitment milestones, such systems can enhance preparation assurance, strengthen readiness analytics, and support sustainable force development.

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Thematic 1 : Physical Performance tests and readiness indicators

#46802857
Poster Presentation

Assessing Nicotine Use Behaviours and Military Readiness: Validity and Reliability of the Military Nicotine Use Questionnaire

BACKGROUND

Previous research has highlighted tobacco smoking as an independent risk factor for musculoskeletal injury (MSKI) during military training. While tobacco smoking behaviour has declined in recent years, e-cigarette use has risen rapidly. Although intended as a smoking cessation aid, nicotine inhalation from e-cigarette use remains a potential concern with respect to military readiness. This is particularly true in the UK, where more than a quarter of Armed Forces personnel are from a sub-population (<25 years) who report high and regular e-cigarette use. Evidence indicates that e-cigarette use may have more acute toxicity than tobacco smoking and unknown long-term impacts. Due to the potential harmful health effects of e-cigarettes for Force readiness, a low burden measurement tool for quantifying nicotine use behaviours is needed. This study investigated the convergent validity (CV) and test-retest reliability of the Military Nicotine use Questionnaire (MNuQ) in military personnel.

METHODS

MNuQ reliability was assessed (n 62) via test-retest protocol (at least >1 week apart) capturing the use of all tobacco, e-cigarettes, nicotine pouches and other nicotine products. CV was assessed (n 53) by collecting nicotine product waste for at least 7 days and comparing product use with MNuQ responses. Test-retest reliability was analysed using intraclass correlation coefficients for individual subcategories; CV was assessed using Cohen's Kappa (κ), t-test and Bland-Altman analysis.

RESULTS

Reliability was very good across subcategories (r = 0.76-0.95; SD = 0.786-5.086; % coefficient of variation ranged 32.2 - 74.7%; $p<0.001$). CV indicated moderate to substantial agreement between questionnaire responses and direct measures of behaviour. Agreement was substantial for nicotine content of e-cigarettes (k = 0.702, $p<0.001$), nicotine pouch replenishment frequency (k = 0.774, $p<0.001$), smoking frequency (k = 0.791, $p<0.001$) and moderate for e-cigarette replenishment frequency (k = 0.454, p = 0.001).

No significant systematic differences were observed between measures for nicotine content of e-cigarettes ($t52$ = 1.30, p = 0.198), e-cigarette replenishment frequency ($t52$ = -0.19, p = 0.851), nicotine pouch replenishment frequency ($t52$ = 0.00, p = 1.000), or smoking frequency ($t51$ = 1.32, p = 0.193). Mean differences were small across variables (range -0.06 to 0.36 category units). Bland-Altman analysis demonstrated narrow limits of agreement for e-cigarette nicotine content (-0.19 to 0.91), with wider limits observed for frequency measures such as e-cigarette replenishment frequency (-4.34 to 4.23), smoking frequency (-2.80 to 3.38) to nicotine pouch replenishment frequency (-4.09 to 4.09).

CONCLUSION

The MNuQ provides a reliable and valid method for estimating nicotine use behaviours in military personnel.

MILITARY IMPACT

With the growing prevalence and increasing complexity of nicotine use, it is important to be able to quantify and monitor nicotine use behaviours in military populations. These nicotine use behaviours may have a direct impact on the health and readiness of military populations.

AUTHORS

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Thematic 1 : Physical Performance tests and readiness indicators

#46806464
Poster Presentation

The effects of acute respiratory infections on maximal endurance performance – 12-month follow-up

BACKGROUND
Acute respiratory infections (ARI) account for a significant proportion of workplace absenteeism and negatively affect on-the-job productivity. However, ARIs effect on physical performance is poorly understood. Possible effects of ARIs on VO2max and cardiac output have been presented but the results are conflicting. The purpose of this study was to investigate the impact of ARIs on physical performance in prospective follow-up.

METHODS
Thirty-six recreational runners participated in a prospective 12-month follow-up study. Maximal endurance capacity was assessed under laboratory conditions using a maximal incremental running test with respiratory gas analysis four times during the follow-up: at baseline and at 4, 8 and 12 months. During the follow-up, participants reported daily ARI symptoms in a symptom diary. Symptoms were defined as throat ace, cough, runny nose, fatigue, changes in taste or smell, chest discomfort or shortness of breath lasting at least one day. Symptom severity was evaluated on a 0–3 scale. A severity score (SS) for each ARI episodes was calculated as the sum of all symptoms during the first five days (maximum value 105). A symptom episode was defined as consecutive symptomatic days separated by at least seven asymptomatic days before the next episode. Each 4-month period was treated as a separate case, and the percentage change in VO2max (%ΔVO2max) was calculated from the test performed at the beginning and end of each 4-months period. The effects of summed symptom days (SSD), SS and consecutive healthy days before the latter test (CHD) on performance were analyzed using the Mann-Whitney U-test by comparing participants who improved (group 1) or did not improve (group 2) their VO2max (defined as change greater than ± 1 SD). In addition, multiple linear regression analysis was conducted to examine whether SSD, SS or CHD significantly predicted changes in VO2max. The study was approved by the Human Sciences Ethics Committee of the University of Jyväskylä (534/13.00.04.00/2023).

RESULTS
A total of 92 four-month periods were analyzed. ARI symptoms were reported in 53 % of the periods. The mean SSD per period was 8.0 (±11.4) days, the mean SS per ARI episode was 21.0 (±13.8), and the mean CHD was 45.7 (±33.5) days. There were no significant differences between the groups 1 and 2 in VO2max change with respect to SSD (8.5 (± 15.6) vs. 7.0 (± 6.4) days, p = 0.371), SS (16.4 (± 5.6) vs. 21.3 (± 13.7), p = 0.755), or CHD (54.0 (± 46.2) vs. 55.3 (± 35.4) days, p = 1.000). The regression model was not statistically significant (R2 = 0.425, p = 0.197).

CONCLUSION
ARIs did not appear to impair maximal physical performance during the prospective follow-up. Although a few moderate ARI episodes occurred, most infections were mild, which may limit the generalizability of the findings to more sever cases. Furthermore, this study does not address the acute effects of ARIs on performance, as all performance tests were conducted only when participants were healthy.

MILITARY IMPACT
Military settings expose soldiers to physical and psychological stressors as well as high pathogenic loads, particularly in barracks conditions. Information on the impact of ARI's on soldiers' performance is highly relevant for mission success and supports leadership decision-making. Although current scientific evidence is limited, ARIs may impair not only physiological but also cognitive performance. Future research should therefore focus on both domains, and particularly on acute changes

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Thematic 1 : Physical Performance tests and readiness indicators

#46810603
Poster Presentation

2 km Run Time as a Predictor of Multi-Stage Shuttle Fitness Test Performance in Military Personnel

BACKGROUND
The British Army currently assess applicant, recruit and serving personnel aerobic fitness primarily using a 2 km run, with a Multi-Stage Shuttle Fitness Test (MSFT) used as an alternative when required. The British Army had a requirement to quantify the relationship between the 2 km run and MSFT performance so the tests could be used interchangeably. The aim of this study was to quantify the relationship between 2 km run time and MSFT performance in British Army recruits and serving personnel.

METHODS
Data were collected for 3158 participants (British Army Recruits and Serving personnel). Participants completed a best-effort 2 km run on surfaced roads/tracks around their training establishment and an MSFT in the gymnasium, separated by at least 48 hours. Performance data are reported as mean ± one standard deviation (SD) with the range of performance scores also reported. Distribution of 2 km run time (s) and MSFT total distance (m) were assessed visually via histograms. The 2 km run times were right skewed and transformed using negative reciprocal before analyses. An Ordinary Least Squares (OLS) regression was used to describe the linear relationship between 2 km run time (s) and MSFT total distance (m) .

RESULTS
Data were removed from the analysis for 533 participants (n = 97, 2 km was reported as not best effort; n = 43, no available MSFT data; n = 393, no available 2 km run time). A total of 2625 observations were included in the final analyses (n = 2424 male, n = 193 female, n = 8 unavailable; age 21 ± 5 years; height 1.77 ± 0.08 m; body mass 74.9 ± 17.4 kg, 2 km run time 533 ± 68 s, MSFT 1503 ± 342 m). The resulting OLS equation was MSFT Distance (m) = -562.33 – 1084727.75 * (-1/2 km run time [s]), R2 = 0.511, p < 0.001. Thus, 51% of the variance in MSFT performance can be explained by 2 km run time. For example, the British Army Ground Close Combat 2 km Role Fitness Test (Entry) standard Level 1 of 08:15 equates to 1620 m (9.11 shuttles).

CONCLUSION
Results indicate that the 2 km run can be substituted for the MSFT in military populations in response to specific field-based situations.

MILITARY IMPACT
Providing a direct conversion between the two tests ensures that the MSFT can be used as a logistically simple substitute for the 2 km run without losing accuracy in assessing aerobic performance of military personnel as an indicator of readiness for the physical demands of high-intensity conflict.

AUTHORS

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Thematic 1 : Physical Performance tests and readiness indicators

#46812501
Poster Presentation

Laboratory Precision vs. Field Practicality: Agreement Between Bioelectrical Impedance Analysis and Dual-Energy X-Ray Absorptiometry in British Army Personnel

BACKGROUND
Accurate assessment of body composition is essential for monitoring operational readiness, physical performance, and injury risk in military personnel. Dual energy X ray absorptiometry (DXA) is the reference method for assessing lean mass and body fat, but its use in field settings is limited by cost, portability, and accessibility, and exposes participants to ionising radiation. Bioelectrical impedance analysis (BIA) offers a rapid, portable, and low-burden alternative. This study evaluated the agreement between two BIA devices and DXA and assessed the inter-device agreement of the two BIA devices, in serving British Army infantry soldiers.

METHODS
Lean mass (kg) and body fat (kg) was measured using two Tanita BIA devices (MC-780 MA NS, Tanita) (BIA 1 and BIA 2) and DXA (iDXA, GE Lunar) in infantry soldiers in the British Army's Welsh Guards (n=46, male = 46, age 20-44 years old). Agreement between devices was assessed using Bland–Altman analysis. Mean bias and 95% limits of agreement (LoA) were calculated, and proportional bias was examined visually. Inter-device agreement between the two BIA devices was also assessed using Bland–Altman plots.

RESULTS
Both BIA devices demonstrated consistent systematic differences when compared with DXA. BIA underestimated lean mass compared with DXA by (mean [95% LoA]) 2.35 [-6.84 to 2.14] kg for BIA 1 and 2.44 [-7.17 to 2.29] kg for BIA 2, indicating large individual-level variation and poor agreement. BIA overestimated body mass compared with DXA by 2.77 (-1.83 to 7.37) kg for BIA 1 and 2.87 (-1.70 to 7.43) kg for BIA 2, with some indication of proportional bias at higher fat levels. The two BIA devices had good agreement, with minimal bias and narrow LoA for lean mass (0.04 [-1.54 to 1.62) kg) and body fat (0.02 [-1.11 to 1.15] kg).

CONCLUSION
The good agreement between two BIA devices means they can be used interchangeably in military field settings, however, the large limits of agreement in lean and body fat mass outcomes against gold-standard reference methods means that individual-level data should be treated with caution and should not be used for clinical decision making.

MILITARY IMPACT
The BIA method may be suitable for population-level monitoring purposes in large groups of military personnel. Although BIA offers a practical, time-efficient approach to measuring body composition in large groups of individuals in field conditions, it is unable to replace laboratory gold-standard reference measures.

AUTHORS

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Thematic 2 : Nutrition and sustained physical performance

Salle Lucienne et André Blin - Mod: C. Thomas + J. Fallowfield

ORAL PRESENTATIONS

Folate and B12 status in women during British Army basic training: a prospective cohort study exploring implications for endurance performance and bone density and metabolism

Nutrition as a Military Capability to Deliver Battlefield Advantage; A System of Systems Model

Energy Needs Assessment, Stress-Related Metabolite Shifts, and Performance Implications in United States Navy Explosive Ordnance Disposal Dive Candidates

Lower Carbohydrate Feeding Models as a Strategy to Deliver Operational Performance Advantage

Protein nutrition as a countermeasure for anabolic resistance following sleep loss in military personnel

Optimising Soldier Readiness: Nutrition Education Reduces Lean Mass Loss During Special Forces Selection

POSTER PRESENTATIONS

Diet Quality in Male Army Reserve Soldiers: Preliminary Results

Operationalizing Nutrition: Lessons Learned Across Navy Populations

Dietary Supplementation as a Countermeasure to Neurobiological Stress During Intensive Special Operations Training: Preliminary Plasma Biomarker Findings

Bone Calcium Balance Following an Antarctic Expedition

From Fireline to Battlefield: Wildland Firefighting as a Model for Studying Warfighter Physiological Stress and Resilience

Structured Nutritional Management During Infantry Training Improves Body Composition and Feeding Perceptions

Nutritional intake in a military context: in the field, on base and at home

Effects of Carnosine Supplementation on Muscular and Cardiorespiratory Endurance in a Large, Placebo-Controlled Adult Cohort

Human Peak Performance in Special Operations Forces: Leaky Gut Syndrome in Special Operation Forces (SOF)

An Army Marches on its stomach: A Systematic Review of the Impact of Dietary, Prebiotic, Probiotic or Synbiotic Supplement Intervention on the Gut Microbiome and Gut Health in Military Personnel

Energy and Macronutrient Intakes were not Optimal among Military Instructors during Field Exercises

A Research-Informed Approach to Developing a Dietary Supplement Policy for Canadian Special Operations Forces Command (CANSOFCOM)

Relationship Between Average Energy Balance and Body Composition in Male and Female Recruits During Marine Corps Basic Training

Thematic 2 : Nutrition and sustained physical performance

#46406259
Oral Presentation

Folate and B12 status in women during British Army basic training: a prospective cohort study exploring implications for endurance performance and bone density and metabolism

BACKGROUND
Folate and vitamin B12 are essential B vitamins, which play critical roles as co-enzymes in the one-carbon metabolic pathway responsible for DNA synthesis, DNA repair, and amino acid metabolism. Folate and B12 deficiency can result in megaloblastic anaemia¾large abnormal pre-cursor erythrocytes¾due to failure of DNA synthesis, cell division, and erythropoiesis; and, lower bone mineral density and higher fracture risk due to an increase in homocysteine. This study investigated changes in serum folate and B12, and associations with endurance performance and bone outcomes, in women during military training.

METHODS
Female soldier and officer trainees (n = 137) had serum folate and B12, haematological markers, and endurance performance (2.4 km run) measured at the start (week 1) and end (week 13) of British Army basic training. Whole-body areal bone mineral density and bone metabolism were measured at week 1. Changes in serum folate and B12, haematological markers, and endurance performance were compared between week 1 and 13 using paired samples t-tests or Wilcoxon-signed rank tests. Multiple linear regression was used to test associations between serum folate, serum B12, haemoglobin, and RBC with 2.4 km run time and bone outcomes (whole-body areal bone mineral density, c-telopeptide cross-links of type I collagen, and procollagen type I N-terminal propeptide) at week 1.

RESULTS
Training decreased serum folate (mean change [95% CI], −2.3 [−3.0, −1.6] nmol•L-1, p < 0.001), B12 (−16 [−32, 0] pmol•L-1, p = 0.042), haemoglobin (−0.7 [−0.9, −0.5] g•dL-1, p < 0.001), and red blood cell count (−0.2 [−0.3, −0.2] × 10^9•L-1, p < 0.001), but had no effect on mean corpuscular volume (p = 0.438) or erythrocyte distribution width (p = 0.088). The prevalence of deficiencies and haematological abnormalities at week 1 and week 13 were: folate deficiency (<4.5 nmol×L-1) = 6.6% and 21.1%; B12 deficiency (<73 pmol×L-1) = 0.0% and 0.0%; anaemia (haemoglobin <12 g•L-1) = 0.7% and 4.4%; macrocytosis (mean corpuscular volume >100 fL) = 7.3% and 13.1%.

There was no association between serum folate, serum B12, haemoglobin, or red blood cell count with 2.4 km run time (p ³ 0.518). Serum B12 was not associated with bone mineral density or bone metabolism at week 1 (p ³ 0.152). Higher serum folate was associated with lower plasma c-telopeptide cross-links of type I collagen (standardised β [95% CI] = -0.31 [−0.48, −0.15], p < 0.001) but not bone mineral density or plasma procollagen type I N-terminal propeptide (p ³ 0.152) at week 1.

CONCLUSION
Serum folate and B12 decreased after military training in women, resulting in a high prevalence of folate deficiencies. Low serum folate may contribute to increased bone resorption due to elevated homocysteine stimulating osteoclast activity.

MILITARY IMPACT
Nutritional strategies should focus on improving folate status for Servicewomen in arduous training¾a population at high risk of bone stress injuries.

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Thematic 2 : Nutrition and sustained physical performance

#46701162
Oral Presentation

Nutrition as a Military Capability to Deliver Battlefield Advantage; A System of Systems Model

BACKGROUND
Military personnel must maintain high levels of readiness to endure extended and/or repetitive periods of physical and cognitive activity during training and operational activities, with unpredictable rest and recovery. Nutrition and diet behaviours provide the foundation for military health, sustaining normal function, supporting resilience, and enhancing training efficacy and operational performance. However, the potential benefits of military feeding as a force multiplier have historically been impaired by the quality of food provision, as well as Warfighter nutrition knowledge and volitional dietary behaviours. A system-based approach to military nutrition has been proposed; developing strategic feeding solutions as a military capability. However, translating this concept into practice across complex, geographically dispersed military organisations has been challenging.

METHODS
An international multi-disciplinary team (MDT) of military food and nutrition subject matter experts convened to operationalise the military nutrition capability concept into a defined delivery model. The team comprised food technologists, nutritionists, physiologists, behavioural scientists and military logisticians. The core functions that should comprise the capability, and the necessary articulations between these capabilities, were identified. Overarching lines of governance were proposed and the respective power-balances elucidated. Finally, the proposed delivery model was challenged with respect to operating across in-garrison and operational feeding contexts. Findings. The MDT identified that a military nutrition capability should comprise a “system of systems”, where each system is a necessary core element to realising the benefits of food and nutrition. The five integrated elements of the System of Systems (SoS) included: research and development (developing evidence-based nutrition strategies); food production (growing, processing and manufacturing functions); logistics (supply chain integration and management); human performance (prepare-perform-recover cycle); and data management (measure, monitor and manage system improvements).

Central to the SoS operation is military leadership; owning the policies, setting the plan, prioritising the programmes and receiving feedback on process outcomes to provide overarching direction and governance.

CONCLUSION
To maximise beneficial performance impacts, militaries must shift their thinking to recognise the importance of food and nutrition as an essential military capability. Adopting a SoS approach provides greater clarity of the nutrition capability core elements and their integration and coordination.

MILITARY IMPACT
Military feeding has failed to realise its full human performance enhancing potential. A SoS model articulates the organisational, cross-cutting coordination of functional elements necessary to deliver benefits from food and nutrition and realise a Return on Investment.

AUTHORS
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Thematic 2 : Nutrition and sustained physical performance

#46708103
Oral Presentation

Energy Needs Assessment, Stress-Related Metabolite Shifts, and Performance Implications in United States Navy Explosive Ordnance Disposal Dive Candidates

BACKGROUND

Military divers are highly trained warfighters who perform various underwater operations. High-stress training during military diver accession is associated with inflammation, oxidative stress, and immune perturbations, and requires adequate energy intake to support recovery and prevent injuries. This research aimed to quantify the energy needs of United States Navy Explosive Ordnance Disposal (EOD) dive candidates and to evaluate the influence of dive training on specific metabolic pathways.

METHODS

Male divers (23±3.2 y, n=40) were enrolled at Recruit Training Command, Great Lakes, Illinois, during the first week of Navy EOD Preparatory and Assessment and Selection (PS) courses. Participants were assessed during 1 week of PS, and for those who successfully graduated, 1 week of training at dive school (DS; Panama City, Florida). Body weight (BW), body fat (BF%), and blood samples (dried blood spot [DBS]) were collected on Days 1 and 7 during training. Doubly labeled water (DLW; 1.5 g/kg) was used to measure total energy expenditure (TEE), and daily dietary intake was assessed via weighed food and digital photography during each training period. Physical training consisted of twice-daily exercise bouts (~1-2 h), including a combination of endurance (swimming, running), calisthenics (push-ups, pull-ups, sit-ups), and other dynamic activities (fireman's carry, bear crawl). DBSs were analyzed for shifts in metabolites using untargeted metabolomics, utilizing a Waters Acquity ultra-performance liquid chromatography and a Thermo Scientific Q Exactive high resolution/accurate mass spectrometer interfaced with a heated electrospray ionization source and Orbitrap mass analyzer. ANOVA was used to identify differences in BW, BF%, TEE, dietary intake, and biochemicals between pre/post training. False discovery rate (q-value) was calculated to account for multiple comparisons. Significance was set at $p<.05$ and $q<.10$.

RESULTS

Participants were White (99%), male (PS: n=40, 22.9 y; DS: n=19, 22.5 y) EOD dive candidates. At PS, there was a decline in BW (-2.9±0.3 kg; $p<.001$), BF% (-1.7±0.3 %; $p<.001$), and lean body mass (LBM; -1.3±0.4 kg; $p=.003$). At DS, no change in LBM was detected but there was a decline in BW (-0.8±0.3 kg; $p=.03$) and BF% (-1.5±0.4 %; $p=.002$). TEE measured via DLW was 5253±171 and 4556±247 kcal/d at PS and DS, respectively. Inadequate dietary intake resulted in an energy deficit of -1960±147 kcal/d (intake = 3187±194 kcal/d) and -2025±311 kcal/d (intake = 2289±93 kcal/d) at PS and DS, respectively. In total, 539 of 946 identified metabolites increased, with largest fold increases (>4x; p and $q<.05$) related to fat metabolism (3-hydroxybutyrate, acylcarnitines), bile acids (cholate, chenodeoxycholate), and hemoglobin degradation (bilverdin, bilirubin-related metabolites). Metabolites related to physiological stress (cortisol, 2-hydroxybutyrate/2-hydroxyisobutyrate), inflammation (14-HDoHE/17-HDoHE), and oxidative stress (7-methylguanine) were also elevated (>4x; p and $q<.05$).

CONCLUSION AND MILITARY IMPACT

Negative energy balance and demanding physical stress over a short period of time was related to extensive metabolite shifts, indicating metabolic and physiological stress in Navy divers. A mismatch of meal timing to training was also observed at DS that may have impacted these outcomes. These data will be used to develop training and diet-based countermeasures to optimize readiness in EOD dive candidates.

AUTHORS

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Thematic 2 : Nutrition and sustained physical performance

#46775945
Oral Presentation

Lower Carbohydrate Feeding Models as a Strategy to Deliver Operational Performance Advantage

BACKGROUND
Military nutrition guidelines promote high carbohydrate and moderate fat intakes, aligned with public health and sport. However, requirements of land-based military personnel differ from these contexts. Modern operational activity may require personnel to carry equipment and food over extended durations. Lower carbohydrate, higher fat (LCHF) feeding models may promote beneficial physiological adaptations to support sustained military activity, while reducing logistical factors including food weight and volume. Thus, a rationale exists to explore a LCHF dietary approach for land-based operations.

METHODS
A series of studies investigated LCHF provision during military operational activity. In Study 1, a group (n 12) consumed a new Rapid Insertion Ration (RIR; Energy as carbohydrate [CHO] 39%; fat 47%; protein [PRO] 12%) during a 7-day Field Exercise, while a control group (n 12) consumed the in-service Operational Ration Pack (ORP; CHO 45%; fat 39%; PRO 13%). Anthropometry, physical strength, sleep, and blood biomarkers were measured at baseline, Day -1 prior, Days 4 and 7 during, and seven days post Field Exercise. Movement activity data (GENEActiv) were collected throughout. Study 2 assessed a one-week pre-deployment LCHF diet (CHO 14%; Fat 66%; PRO 19%; n 5) designed in collaboration with military chefs, with a Control group (n 7) consuming standard food provision. Both groups consumed the RIR during a 4-day Field Exercise. Anthropometry, physical strength and power, and mood state were measured at baseline, Day -1 prior, and Day 4 post Field Exercise.

RESULTS
At 4000 kcal provision, the RIR was 36% lighter than ORP. In Study 1, the RIR group performed greater moderate-vigorous intensity activity during the Field Exercise (RIR: 368±44 mins; Control: 321±38 mins; $p<0.05$). Independent military subject matter experts asserted that the RIR group performed better on Military Tasks. In Study 2, the LCHF group had improved mood state compared to Control post-Field Exercise. Anthropometry and physical performance changes were not apparent between groups in Study 1 or 2. In both studies, focus groups and questionnaires identified improved taste and texture, and reduced volume and weight of the RIR compared to the ORP.

CONCLUSION
A LCHF ration and pre-deployment diet were not detrimental to physical performance and reduced the weight and volume of rations carried compared to in-service provision. Research with larger sample sizes is required to determine whether pre-deployment LCHF diets cause physiological changes that deliver operational advantage.

MILITARY IMPACT
The requirements of land-based operational feeding are different to sport. Alternative approaches to operational feeding that challenge performance nutrition norms may provide performance benefits to contemporary operational activity. The delivery of LCHF food provision is feasible in deployed contexts and presents plausible physiological and logistical implications that may facilitate battlefield advantage.

AUTHORS

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Thematic 2 : Nutrition and sustained physical performance

#46804394
Oral Presentation

Protein nutrition as a countermeasure for anabolic resistance following sleep loss in military personnel

BACKGROUND
Sleep loss is a common stressor in military operations, leading to dysregulated hormone concentrations which impair muscle protein synthesis (MPS) and contribute to declines in muscle mass and physical performance. Whether these effects extend to whole-body protein balance (WBPB) and if consuming increased dietary protein and altering protein distribution after sleep loss enhances recovery of MPS and WBPB is unknown. This study examined the effects of sleep loss on MPS and WBPB, and whether protein distribution during recovery impacts these markers.

METHODS
Twenty Soldiers (mean±SD; age: 23 ± 5y, BMI: 26 ± 3 kg/m2) completed a 14d randomized, parallel study including a 7d sleep satiated phase (7–9h sleep/d; Satiated), 4d sleep restriction phase (4h sleep/d; Restriction), and 3d recovery phase (7–9h sleep/d; Recovery). Sleep was monitored with actigraphy (Phillips Actiwatch) and staff oversight. During Recovery, volunteers randomly consumed protein as an even (n=10) or skewed (n=10) distribution across 4 daily meals. Individualized, eucaloric diets included meal, ready-to-eat rations and commercial foods; Satiated and Restriction: 1.1 ± 0.0 g protein/kg/d, 4.8 ± 0.6 g carbohydrate/kg/d, 1.2 ± 0.2 g fat/kg/d, and Recovery: 1.6 ± 0.0 g protein/kg/d as Even (~0.4/0.4/0.4/0.4 g/kg/meal) or Skewed (~0.11/0.27/1.15/0.07 g/kg/meal) distribution, 4.8 ± 0.4 g carbohydrate/kg/d, 1.1 ± 0.1 g fat/kg/d. Daily exercise (55% VO2peak) expended 467 ± 54 kcals. Integrated MPS was estimated with deuterium oxide, saliva and blood sampling, and muscle biopsies. WBPB was estimated with 15-N alanine and 24h urine collections. Linear mixed models estimated the effects of phase, protein treatment, and any interaction on MPS and WBPB. Statistical analyses were performed with SPSS (ver. 26; IBM Corp. USA) and significance was P = 0.05. Volunteers provided informed consent. The study was approved by the US Army Human Research Protections Office IRB (#M11046). Investigators adhered to the policies for protection of human participants as prescribed in DODI 3216.02, and the research was conducted in adherence with the provisions of 32 CFR Part 219.

RESULTS
Per protocol, sleep duration was lower (P < 0.05) during Restriction (4.0 ± 0.4 h sleep/d), compared to Satiation (7.3 ± 0.5 h sleep/d) and Recovery (7.2 ± 0.7 h sleep/d), with no differences between Even vs. Skewed (P = 0.451). MPS was reduced by ~25% from Satiation (1.5 ± 0.3 %/d) to Restriction (1.1 ± 0.2 %/d, P < 0.01) but did not differ between Satiation and Recovery (1.3 ± 0.4 %/d, P = 0.384) or Restriction and Recovery (P = 0.114). MPS did not differ between protein treatments. WBPB did not change from Satiation (9.3 ± 7.7 g/kg/d) to Restriction (8.2 ± 9.3 g/kg/d, P = 1.0), but was greater during Recovery (17.8 ± 12.7 g/kg/d) vs. Satiation (P < 0.05) and Restriction (P < 0.001). WBPB did not differ between protein treatments.

CONCLUSION
Sleep loss reduces MPS despite moderate daily exercise. Consuming 1.6 g protein/kg/d concurrent with recovery sleep after a period of restricted sleep supports increased WBPB with no immediate impact on MPS and no effect of protein distribution.

MILITARY IMPACT
These findings inform ration development and support nutrition and sleep guidance following high-intensity operations involving sleep loss. Soldiers should seek to consume protein at intakes of ~1.6 g/kg/d and achieve sufficient sleep opportunities to sustain recovery and readiness. Funding Sources: USAMRDC; not official US Army/DoW policy.

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Thematic 2 : Nutrition and sustained physical performance

#46818294
Oral Presentation

Optimising Soldier Readiness: Nutrition Education Reduces Lean Mass Loss During Special Forces Selection

BACKGROUND
Highly strenuous military training courses, such as Special Forces Selection courses, expose soldiers to prolonged physical activity combined with food and sleep deprivation. These stressors cause substantial losses in body mass, lean mass and physical performance, potentially reducing operational readiness.Strategies to mitigate these effects without compromising training integrity are essential. This study quantified energy deficit and body composition changes during a three-week Australian Special Forces Selection Course (SF-SC), and compared outcomes following implementation of a nutrition-focused intervention in a subsequent cohort.

METHODS
A total of 199 healthy male participants (means ± SD; age: 28 ± 4 y, height: 1.81 ± 0.06m, body mass: 85.2 ± 7.8kg, lean mass: 71.8 ± 6.2 kg, fat mass: 11.5 ± 2.9 kg) attempted the three-week Australian Special Forces Selection Course in 2021 (n=93) or 2023 (n=106). In 2021, average daily energy expenditure (via Doubly Labelled Water) and dietary intake were assessed to determine macronutrient and energy intake, and energy deficit. In both cohorts, body mass, lean mass and fat mass were measured at baseline and two days post-course by digital scale and Dual X-Ray Absorptiometry.Between courses, a nutrition education booklet – based on 2021 observations – was provided to all 2023 SF-SC candidates, and guidance was issued to staff to increase access to carbohydrates and improve nutrition opportunities when appropriate within the course. Paired t-tests assessed pre-post changes in body composition for each cohort. One-way ANOVAs were used to compare changes in body composition between cohorts (2021 vs 2023) Effect sizes were calculated as partial eta squared (h2), with h2=0.01, h2=0.06 and h2=0.14 indicating a small, medium, and large effect respectively.

RESULTS
Mean total daily energy expenditure and deficit during the first 10 days of the 2021 course was: expenditure: 7680 ± 1095 kcal.day-1; deficit: 3823 ± 1256 kcal.day-1.Average protein intake ranged between 0.3 – 1.9 g.kg.day-1, and average carbohydrate intake ranged between 0.7 – 7.2 g.kg.day-1 throughout different phases of the course. Twenty participants completed the course each year and were included in the analysis.Baseline body mass and fat mass did not differ between cohorts; however, baseline lean mass was higher in 2023 (73.2 ± 5.3 vs 69.9 ± 4.5kg, $p<0.05$). Both cohorts demonstrated significant reductions in body mass (2021: −6.8 ± 1.9 kg, $p < 0.001$; 2023: -5.6 ± 2.5kg, $p<0.001$), lean mass (2021: −3.0 ± 1.7 kg, $p < 0.001$; 2023: -1.4 ± 2.5 kg, $p=0.02$) and fat mass (2021: −4.2 ± 1.0 kg, $p < 0.001$; 2023: -4.3 ± 1.5kg, $p<0.001$) due to SF-SC. Lean mass loss was significantly lower, by 51.8%, in 2023 compared to 2021 ($p=0.03$; $h2=0.12$), whereas total body mass and fat mass losses did not differ between cohorts ($p>0.05$, $h2=0.08$ and 0.01, respectively).

CONCLUSION
The SF SC produced substantial losses in body mass, fat mass, and lean mass. However, a targeted nutrition education intervention attenuated lean mass loss, supporting improved recovery and readiness following the course.

MILITARY IMPACT
Targeted nutrition education is a practical, low-cost strategy to attenuate lean mass loss during strenuous military training. Improving soldiers' nutritional literacy supports optimisation of health behaviours, even in the context of arduous and deprived conditions, improving operational readiness, and preparing personnel for sustained operational demands.

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Thematic 2 : Nutrition and sustained physical performance

#1000060
Poster Presentation

Diet Quality in Male Army Reserve Soldiers: Preliminary Results

BACKGROUND
A healthy diet supports not only physical and military training but also the prevention of chronic lifestyle-related diseases. Although nutritional requirements can vary considerably according to military task, daily dietary patterns and eating behaviors are fundamental maintaining adequate nutritional status. Therefore, the aim of the study was to examine meal pattern and food intake including main courses, fruit and vegetables, fats, fast food, salty and sugary snacks among Finnish male Army reservists.

METHODS
Altogether 249 men (age 32±9 years, height 180.0±6.8 cm, body mass 86.6±16.2 kg, BMI 26.7±4.7 kg/m2) took part in a military refresher exercise and volunteered for the study. The quality of the diet was assessed by Healthy Diet Index -questionnaire in the beginning of the exercise (Lindstrom et a. 2021). Questions of meal pattern, main courses and intakes of fruit, berries and vegetables; fats; fast food, salty and sugary snacks were chosen for this study. Results are presented as percentage distributions and means. The study was approved by the Ethical Committee of the Central Finland Healthcare District and Finnish Defence Forces.

RESULTS
Regarding meal pattern, 54% of participants ate breakfast every day, whereas daily lunch and dinner were eaten 86% and 84% of participants, respectively. As main course meals, participants consumed meat dishes an average of 3.2 servings per week, poultry dishes 3.0 servings, fish dishes 1.2 servings, vegetarian dishes 1.2 servings, and sausage dishes 0.9 servings per week. 29% of participants used vegetables and roots and 17 % fruit and berries at least two servings per day. The most common spreads on the bread were butter-vegetable oil mixture (47 %) and margarine, plant stanol or sterol margarine (38%). Fast food meals or salty snack portions were consumed at least 1-3 times per week by 55% of participants. 49% reported the use of sweet pastries, ice cream, puddings or chocolate 1-3 servings per week and 32% less than one serving per week.

CONCLUSION
The results reflect characteristics of a typical Western diet including a low intake of vegetables, fruits, and berries and a high intake of meat and fats from animal sources, and are consistent with recent findings in military settings (Bayes et al. 2025). Regular meal patterns and a plant-based diet could reduce disease risk and support physical training among reservists, thereby contributing to the maintenance of operation capability. Furthermore, nutritional strategies implemented within the military could be effective in improving dietary patterns and nutritional intake while targeting large proportion of population.

AUTHORS

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Thematic 2 : Nutrition and sustained physical performance

#46707692
Poster Presentation

Operationalizing Nutrition: Lessons Learned Across Navy Populations

BACKGROUND
Over the past 5 years, we have assessed energy and nutrient status across several Navy populations to support readiness. In alignment with Pillar 4 of the Chief of Naval Operations' "Sailors First" Guidance (NAVADMIN 186/25), our aim is to summarize best practices, common barriers, and opportunities to enhance the Navy through nutrition.

METHODS
Nutrition and physiological outcomes were assessed across Navy populations: (1) Officer Training Command (OTC, Newport, RI; n=53); (2) Recruit Training Command (RTC, Great Lakes, IL; n=88); (3) Naval Dive and Salvage Training Center (Panama City, FL; n=19); and (4) active-duty sailors (n=166; stationed at one of four bases or deployed). Assessments included energy and nutrient intake and timing, nutrient status via biomarkers (vitamin D, omega-3), and environmental barriers. Best practices and recommendations (e.g., menu, policy, training changes) were identified to enhance readiness.

RESULTS
(1)The galleys at RTC and OTC supported energy and macronutrient needs for most candidates. Standard portions are served independent of body size, resulting in some individuals with insufficient or excess intakes. Strategies, including offering whole-wheat bread and sunflower butter, led to adequate fiber intake in recruits. Opportunities include nutrition education and adding specific nutrient-rich foods. (2) Low energy intake, nutrient timing (breakfast too close to training), and meals consumed outside the galley were key issues identified in EOD candidates. Improvements could be realized with changes in training, nutrient timing, and nutrition education. (3) Base galleys provided food choices that supported operational readiness; a key limitation was access (e.g., location and availability) due to job/personal constraints. Food offerings outside the galley were often suboptimal. An opportunity is identifying ways to improve visibility/offering of nutritious foods with NEX mart, food cart, and commissary management. (4) Vitamin D insufficiency/deficiency (≤30 ng/ml) and poor omega-3 status (~3% omega-3 index) were prominent across the populations assessed (>70% for vitamin D and 100% for omega-3). Suggested policy improvements include offering more foods rich in these nutrients, education, and providing annual status screenings.

CONCLUSION AND MILITARY IMPACT
Leadership continues to be informed of menu recommendations and policy changes to optimize operational readiness via nutrition.

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Thematic 2 : Nutrition and sustained physical performance

#46809098
Poster Presentation

Dietary Supplementation as a Countermeasure to Neurobiological Stress During Intensive Special Operations Training: Preliminary Plasma Biomarker Findings

BACKGROUND
Canadian Special Operations Forces (SOF) training to prepare and endure high-intensity conflict can involve repeated blast overpressure, heavy weapons, whole-body vibration, sleep restriction, and prolonged multi-domain physical and cognitive loading. These occupational stressors may elicit subclinical neuroaxonal and astroglial stress. Nutritional supplementation is a scalable, low-burden countermeasure, but human field evidence in SOF settings remains limited.

METHODS
In a naturalistic, dietitian-guided field study conducted during two intensive SOF training courses, participants either followed a targeted supplementation regimen (creatine monohydrate, omega-3 fatty acids [O3FA], and vitamin [Vit-D3]) or served as controls (no supplementation). Venous EDTA plasma was collected at five timepoints (T1–T5) per course. O3FA index (O3I) and Vit-D3 were measured to confirm uptake and to support individualized dosing guidance. Ten neurological biomarkers were quantified by ultrasensitive single-molecule array, spanning tau-related neuronal cytoskeletal stress/phosphorylation (total tau; p-tau181, p-tau217, p-tau231; brain-derived tau [BD-tau]), astrocyte injury/reactivity (GFAP), axonal injury (NfL), neuronal cell-body injury (UCH-L1), and amyloidogenic peptides (Aβ40, Aβ42). Between-course comparisons used independent-samples tests; within-course effects used one-way repeated-measures ANOVA. All procedures were approved by DRDC Human Research Ethics committee. A third course is underway to increase power and improve exposure characterization.

RESULTS
Twenty-nine male SOF personnel were assessed (Course 1: controls n=4, supplemented n=5; Course 2: controls n=4, supplemented n=16). Supplemented participants maintained higher O3I and Vit-D3 than controls throughout training, confirming biological engagement. No biomarker showed a significant main effect of time within either course (all $p>.05$), indicating no progressive escalation across the monitored training periods. Pooled across timepoints and groups, Course 2 exceeded Course 1 for p-tau181 ($p=.0078$), p-tau217 ($p=.028$), p-tau231 ($p<.001$), NfL ($p=.015$), and UCH-L1 ($p=.046$), while total tau, GFAP, and Aβ40/42 did not differ (all $p\geq.23$), consistent with course-specific exposure differences. Exploratory within-course comparisons suggested a favorable signal in supplemented participants, with directionally lower BD-tau and GFAP during Course 1.

CONCLUSION
Multi-nutrient supplementation during intensive SOF training was feasible and confirmed measurable uptake, with sustained increases in O3I and Vit-D3 concentrations relative to controls. Although underpowered for small effects, preliminary patterns–particularly directionally lower neuronal/astroglial markers in supplemented personnel during one course–are suggestive of a beneficial modulatory effect of O3FA-based supplementation (with creatine+Vit-D3) on neurobiological stress signals in realistic training environments. Course 3 will clarify effect magnitude and operational relevance, including links to exposure metrics and functional outcomes.

MILITARY IMPACT
Readily deployable nutritional countermeasures may complement “prepare–perform–recover” strategies to support brain health resilience during high-tempo training for high-intensity conflicts; larger studies integrating objective exposure and performance endpoints are warranted.

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Thematic 2 : Nutrition and sustained physical performance

#46217259
Poster Presentation

Bone Calcium Balance Following an Antarctic Expedition

BACKGROUND
Antarctic expeditions involve high exercise volumes and severe energy deficits, which can decrease areal bone mineral density (aBMD), indicative of disturbed calcium homeostasis. Naturally occurring calcium isotopes in urine can quantitatively determine net bone calcium loss and gain. Bone formation favours the uptake of isotopically lighter calcium isotopes, creating a positive bone calcium balance and a shift in urine towards an isotopically heavier state. This study investigated the effect of a prolonged Antarctic crossing on aBMD and bone calcium balance.

METHODS
Nine military and civilian individuals each hauled 85 kg sledges over 911 km across the Antarctic in 47 days. Pre- and post-expedition whole-body aBMD was measured by DXA. Spot urine voids were collected for the measurement of calcium isotope ratio (δ44/42Ca) upon waking pre- (-1 d), during (day 15 and day 30), and post- (+2 d) expedition. Venous blood samples were obtained pre- (-14 d) and post- (+6 d) expedition. All data were analysed using the R programming language. Pre- and post-expedition data were compared with either a paired sample t-tests or Wilcoxon signed-rank tests. Linear mixed effect models with restricted maximum likelihood estimation were used to examine effects of time on urine δ44/42Ca.

RESULTS
Body mass (-2.6 kg [-4.7, 00.5]), body fat percentage (-4.9 kg [-6.9, -3.0]), and aBMD (-0.05 g·cm-2 [-0.08, -0.02]) decreased from pre- to post-expedition ($p \leq 0.022$). There was no overall change in group-level urine δ44/42Ca throughout the expedition (η_P^2 = 0.01; p = 0.960), but large inter-individual variability was observed. There was no difference in iPTH (-0.85 pmol·L-1 [3.05, 1.34]), total 25(OH)D (-6.0 nmol·L-1 [-12.6, 0.6]), FSH (0.71 mIU·mL-1 [-0.19, 1.61]), LH (-0.23 mIU·mL-1 [-1.30, 0.84]), female (-86.2 pmol·L-1 [-501.5, 329.2]) or male (43.1 pmol·L-1 [-60.9, 147.0]) oestradiol, or female (0.1 nmol·L-1 [-2.0, 2.2]) or male (2.5 nmol·L-1 [-3.0, 8.0]) testosterone between pre- and post-expedition ($p \geq 0.067$). Thyroid stimulating hormone (0.65 uIU·mL-1 [0.12, 1.18]), and total T3 (0.11 nmol·L-1 [-0.02, 0.24]) increased from pre- to post-expedition (both p = 0.02).

CONCLUSION
The decline in aBMD was likely due to prolonged energy deficit. There was no associated change in bone calcium balance likely because δ44/42Ca tracks short term calcium fluxes from bone and can normalise rapidly, whereas aBMD reflects cumulative changes in mineralised bone mass.

MILITARY IMPACT
Natural calcium isotopes may detect individual acute bone loss more acutely in an environment of extreme exercise stress and energy restriction—which is common to military field exercise and deployments—but spot urine samples do not give a complete picture of chronic bone mass loss. Service Personnel are a population at high risk of bone stress injuries; therefore, strategies to monitor skeletal health non-invasively throughout deployment and field exercise should be considered.

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Thematic 2 : Nutrition and sustained physical performance

#46232096
Poster Presentation

From Fireline to Battlefield: Wildland Firefighting as a Model for Studying Warfighter Physiological Stress and Resilience

BACKGROUND
Modern warfighters operate in environments defined by sustained physical exertion, heavy external load carriage, environmental heat stress, disrupted sleep, nutritional constraints, psychological strain, and limited recovery. Wildland firefighters (WLFFs) represent a high-fidelity and underutilized surrogate model for examining these demands in an ecologically valid setting.

METHODS
Over the past three decades, our research team has completed numerous field-based investigations of WLFFs and employed gold-standard and emerging methodologies, including doubly labeled water, wearable physiological monitoring, ingestible thermometry, biochemical analyses, and task-level observational approaches.

RESULTS
WLFFs perform prolonged manual labor while carrying external loads across steep, uneven terrain, often in hot, smoky, and mountainous environments. Work shifts commonly extend 12–16 hours across consecutive days or weeks, resulting in total daily energy expenditures (TDEE) that frequently exceed 20–25 MJ/day (5,000–6,000 kcal/day, 2.6±0.5 xBMR) with a water influx ranging from 6-10 L/day. WLFFs self-regulate work intensity on assignments and over the duration of the fire season to sustain prolonged operational output yet still experience substantial cumulative physiological stress that challenges metabolic health, muscle glycogen repletion, and cardiovascular and thermoregulatory function. These stressors uniquely mirror the physiological patterns experienced by dismounted warfighters during extended training and expeditionary operations.

CONCLUSION
The working environment of the WLFF offers a rare opportunity to study team-based workload distribution, fitness-dependent resilience, sex-based responses, and the interaction of environmental and occupational stressors under mission-critical conditions. Insights derived from this analog can inform military training doctrine, nutritional strategies, ration development, load management, heat-injury mitigation, and recovery practices aimed at enhancing warfighter performance, readiness, and long-term health.

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Thematic 2 : Nutrition and sustained physical performance

#46519376
Poster Presentation

Nutritional intake in a military context: in the field, on base and at home

BACKGROUND
Adequate and sufficient nutrition is essential for military personnel to perform optimally. Inadequate nutritional intake can lead to reduced health and performance, and an increased risk of injuries and dropouts. Military personnel operate in diverse settings, each characterised by differing food availability and nutritional demands. However, there is limited insight into how these settings influence nutritional intake. Therefore, this study examines energy and nutrient intake of Dutch soldiers in three settings: in the field, on base and at home.

METHODS
72 soldiers from the Dutch light armoured brigade were included in this study. In the field, a food intake/waste method was used to determine the intake of rations. Participants were asked to hand in their packaging waste and fill out questionnaires to assess their energy and nutrient intake. On base and at home, participants recorded their dietary intake using online food diaries. Nutritional intake was compared to the Military Dietary Reference Intakes (MDRI). Energy expenditure on base and at home was measured using online questionnaires. Energy expenditure data in the field was not available.

RESULTS
Fibre intake was below the MDRI in all three settings (20.8-22.6 g/day). Carbohydrate intake was below the MDRI on base and at home (39.9-40.3 E%), while intake in the field met the reference values (51.0 ± 5.5 E%). In contrast, total fat (34.1-36.4 E%), saturated fat (11.3-12.6 E%) and sodium intake (3.9-4.1 g/day) exceeded the MDRI consistently across settings. Protein take (1.1-1.7 g/kg body weight/day) met the MDRI recommendations in all three settings. Energy intake was below the MDRI in the field (2751 ± 736 kcal/day), on base (2787 ± 611 kcal/day) and at home (2748 ± 537 kcal/day), but comparable to energy expenditure on base (2988 ± 431 kcal/day) and at home (2752 ± 346 kcal/day).

CONCLUSION
Despite known limitations with dietary and physical activity assessment, the findings indicate that participants in this study consumed insufficient energy, especially in the field. Since carbohydrate on base and at home, and fibre intake in all settings, were below the reference values, increasing fibre-rich carbohydrate consumption could be an effective strategy to address the energy deficit.

MILITARY IMPACT
This study shows insufficient energy, carbohydrate and fibre intake among soldiers of the Dutch light armoured brigade. Insufficient nutritional intake may compromise soldiers' health, physical performance, and operational effectiveness. Targeted strategies to enhance energy intake, particularly by increasing fibre-rich carbohydrate consumption, may help reduce fatigue, enhance recovery, and support sustained combat readiness, particularly in the field.

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Thematic 2 : Nutrition and sustained physical performance

#46573479
Poster Presentation

Effects of Carnosine Supplementation on Muscular and Cardiorespiratory Endurance in a Large, Placebo-Controlled Adult Cohort

BACKGROUND
Carnosine is an endogenous histidyl dipeptide (β-alanine–L-histidine) highly concentrated in metabolically active tissues, including skeletal muscle and brain. Through its antioxidant activity, metal chelation, and intracellular pH buffering, carnosine supports cellular homeostasis under conditions of metabolic stress. Dietary supplementation with carnosine has therefore been proposed as a strategy to enhance physical and cognitive performance. However, prior placebo-controlled trials have been limited by small sample sizes, narrow demographic representation, and limited assessment of systemic carnosine uptake.

METHODS
We conducted a randomized, double-blind, placebo-controlled trial in which 299 adults were assigned to receive carnosine (2 g/day) or identical placebo capsules for 12 weeks. Clinical assessments occurred at baseline, 6 weeks, and 12 weeks. Physical performance was evaluated at each visit using seven standardized measures of muscular strength and endurance, including calf-raise and two-minute step tests. Blood and urine samples were collected at all visits to quantify carnosine uptake. Mixed-effects models were used to assess absolute and percent changes from baseline and to compare outcomes between treatment groups. The study was approved by the University of Louisville, Institutional Review Board.

RESULTS
Of the 299 randomized participants, 273 completed the study. Participants had a mean age of 44 years (range 23–65), were 42% male, and racially diverse (81% White, 10% Black, 9% other). In the supplementation group, carnosine concentrations increased approximately two-fold in erythrocytes and seven-fold in urine, confirming systemic uptake. After 6 weeks, carnosine supplementation significantly improved calf-raise performance in participants younger than 40 years ($p = 0.018$). After 12 weeks, step-test performance was significantly improved in males older than 40 years ($p = 0.010$), with a near-significant improvement observed in all males combined ($p = 0.06$). No significant effects were observed on grip strength or other indices of maximal strength.

CONCLUSION
Carnosine supplementation selectively enhanced muscular endurance in younger adults and cardiorespiratory endurance in older males, without affecting maximal strength. These findings indicate age- and sex-specific benefits, particularly for tasks involving sustained or repetitive movements under stress.

MILITARY IMPACT
Carnosine supplementation selectively enhanced muscular endurance in younger adults and cardiorespiratory endurance in older males, without affecting maximal strength. These findings indicate age- and sex-specific benefits, particularly for tasks involving sustained or repetitive movements under stress.

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Thematic 2 : Nutrition and sustained physical performance

#46612400
Poster Presentation

Human Peak Performance in Special Operations Forces: Leaky Gut Syndrome in Special Operation Forces (SOF)

BACKGROUND
Prolonged physical exertion, psychological stress, sleep disruption, and environmental exposures are known to affect gastrointestinal physiology and immune regulation. Recent evidence indicates that sustained high-intensity training and chronic stress can impair intestinal barrier integrity, promote dysbiosis, and contribute to systemic inflammatory responses, thereby negatively affecting recovery and performance (Lamprecht et al., 2015; Thompson, 2024). Populations exposed to persistent high operational demands, such as military special operations forces, may therefore be particularly susceptible to gut barrier dysfunction, yet data in this field remain limited. This study aimed to assess intestinal barrier status in active-duty special operations soldiers and to evaluate the effects of an eight-week gut-focused intervention on biomarkers of intestinal permeability, inflammation, and sleep quality.

METHODS
A prospective, controlled study was conducted in male soldiers of the Austrian Special Forces Unit. Participants were allocated to an intervention group or a non-intervention control group. Intestinal health was assessed before and after the intervention using stool-based biomarkers, including zonulin, alpha-1-antitrypsin, calprotectin, and secretory immunoglobulin A (sIgA). The intervention consisted of daily oral zeolite supplementation combined with weekly chelation phases using oral dimercaptosuccinic acid (DMSA) and rectal calcium-EDTA.

RESULTS
At baseline, a substantial proportion of participants exhibited biomarker patterns indicative of impaired intestinal barrier function. Following the intervention, the intervention group demonstrated stability or improvement of multiple gut-related biomarkers, whereas the biomarkers of the control group got worse over time.

CONCLUSION
These findings suggest that a combined zeolite and chelation-based intervention is feasible in a high-performance military setting and may positively influence intestinal barrier integrity and recovery-related parameters. The results provide preliminary evidence supporting gut-targeted strategies as a component of integrated human performance optimization in special operations forces and underline the need for larger, long-term studies to confirm these effects.

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Thematic 2 : Nutrition and sustained physical performance

#46674673
Poster Presentation

An Army Marches on its stomach: A Systematic Review of the Impact of Dietary, Prebiotic, Probiotic or Synbiotic Supplement Intervention on the Gut Microbiome and Gut Health in Military Personnel

BACKGROUND
The gut microbiome is increasingly recognised for its role in supporting physiological processes, health and human performance, with most existing evidence drawn from athletic populations. Military personnel are often described as tactical athletes due to the high physical, cognitive and environmental demands of training and deployment. Although research in military cohorts remains limited, studies into other populations demonstrate that dietary patterns and targeted use of biotics can beneficially modulate the gut microbiome, gastrointestinal health and aid recovery. The aim of this review was to investigate the effect of dietary intervention via whole food or supplementation of prebiotic, probiotic or synbiotics within a military population.

METHODS
A systematic search of the databases EMBASE, Web of Science, PubMed and Scopus was conducted from inception to November 2025, with screening in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The primary outcome was the effect of dietary or supplementation interventions on gut microbiota, with secondary outcomes assessing gut health and other self reported measures. Descriptive data were extracted for study design, participant characteristics, microbiota changes, gut health outcomes and any additional reported findings.

RESULTS
The initial search identified 829 articles; after removing duplicates and screening titles, abstracts and full texts, six studies met the inclusion criteria. One study reported only gut microbiota taxonomy or abundance, while five reported both gut taxonomy and gut related health outcomes. Supplementation with certain formulations of prebiotic and/or synbiotics showed potential to modulate specific taxa or support homeostasis. Measurement methods for gut health outcomes were inconsistent, with no significant differences were observed between intervention and control groups for diarrhoea incidence, bowel movements, or gastrointestinal symptoms. Limited Meal, Ready to Eat studies (n=2) reported negative shifts in gut microbiota taxonomy and the faecal metabolome, with mixed gut health findings.

CONCLUSION
Diet-microbiome interactions in military personnel remain poorly understood, despite some evidence suggesting probiotic and synbiotic supplements may alter gut taxonomy, the benefits for gut health remain unclear. Further studies are needed to determine how diet, supplementation and ration design can be used to support the gut microbiome and improve gut health measures amongst military personnel.

MILITARY IMPACT
Gastrointestinal disturbances are frequently reported among military personnel during modern conflicts, where stress, disrupted routines and suboptimal nutrition place great demands on physiological and cognitive resilience. Evidence shows dietary interventions have the potential to support gastrointestinal health in demanding environments.

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Thematic 2 : Nutrition and sustained physical performance

#46748602
Poster Presentation

Energy and Macronutrien intakes were not optimal among military instructors during field exercises

BACKGROUND
Military personnel are required to meet the high demands of physical and mental performance while operating in challenging environments. Studies suggest that adequate nutrition is essential for sustaining physical performance and operational readiness, especially when the energy expenditure is high. Previous findings demonstrate that daily energy expenditure in comparable exercises typically ranges between 4000 and 5000 kcal. The aim of this study was to assess the energy and macronutrient intake among Finnish military instructors during live-fire field exercise (LFFE) and combat exercise (CE), and to evaluate whether the intakes met nutritional recommendations for soldiers or the Nordic Nutrition Recommendations (NNR). In addition, differences in energy and macronutrient intake between the LFFE and CE were investigated.

METHODS
Sixteen volunteer military instructors (age = 20–34 years; height = 1,76 m ± 0,06; weight = 78,5 ± 9,0 kg; BMI = 24,9 ± 2,3 kg/m2) participated in the study. The data was collected with partially pre-filled food diaries over three consecutive days in LFFE and two consecutive days in CE. The data was analysed using national Food Composition Database Fineli (the Finnish Institute for Health and Welfare). Statistical analyses were completed based on the normality either with t-test or Mann-Whitney u test. The confidence intervals were calculated and the effect sizes defined using Hedges' g.

RESULTS
Daily energy intake (mean and 95% confidence intervals) was 2121 (1898–2344) kcal in the LFFE and 2044 (1837–2252) kcal in the CE. Macronutrient intake were distributed as follows: protein 14 (13–16) E% in LFFE and 16 (14–17) E% in CE; carbohydrate 48 (44–52) E% and total fat 35 (31–38) E% and 35 (33–38) E%, respectively. The protein intake was 1,0 (0,8–1,1) g·kg−1 ·d-1 in LFFE and 1,0 (0,9–1,2) g·kg−1 ·d-1 in CE, whereas carbohydrate intake was 3,2 (2,8–3,7) g·kg−1 ·d-1 and 3,2 (2,7–3,6) g·kg−1 ·d-1, respectively. The sucrose intake was 11 (8–13) E% and 11 (8–13) E%; fibre 20 (18–23) g·d−1 and 23 (20–26) g·d−1; saturated fat 13 (11–14) E% and 10 (9–11) E%; monounsaturated fat 13 (12–14) E% and 14 (13–16) E%, respectively. Polyunsaturated fat intake was lower in LFFE 6 (5–6) E% than in CE 8 (7–8) E%, (p = 0.001, Hedges' g = 0.905). No other significant differences were observed.

CONCLUSION
The results suggest that the self-reported total energy intake was low during both LFFE and CE, which could affect to soldiers' physical, mental or cognitive performance. Additionally, neither protein nor carbohydrate intakes met the nutritional recommendations for soldiers, which could have emphasized the negative effects in soldiers' strength and aerobic capacity. Compared with the NNR the relative values were mostly between the recommended limits, even though protein and carbohydrates were close to the lower limits. During the LFFE, reported sucrose and saturated fatty acid intakes were higher than recommended, whereas during the CE, sucrose intake was over the upper limit. Limitations of this study include small sample size and possible bias in self-reported dietary assessment. Nevertheless, these findings highlight the need to emphasize adequate nutrition during field exercises.

MILITARY IMPACT
Neglecting the nutrition could decrease the ability to operate in challenging environments. The inadequate nutrition could affect not only to individual performance but also unit-level operational capacity.

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Thematic 2 : Nutrition and sustained physical performance

#46782349
Poster Presentation

A Research-Informed Approach to Developing a Dietary Supplement Policy for Canadian Special Operations Forces Command (CANSOFCOM)

BACKGROUND
Consistent with trends observed across other Special Operations Forces (SOF) nations, CANSOFCOM operates under high operational demands, frequently in austere environments, and often with inconsistent access to high-quality nutrition. Although evidence supports the targeted use of select dietary supplements for military personnel, internal assessments revealed inconsistent access and variable use among CANSOFCOM members. With embedded Performance Dietitians uniquely positioned to provide evidence-based, third-party-tested supplementation guidance, the absence of a formal policy represented a capability gap. This project outlines the research-informed process used to establish an organization-wide Dietary Supplement Policy, leveraging both empirical data and the expertise of embedded CANSOFCOM dietitians.

METHODS
CANSOFCOM's Human Performance Research & Development team (HP R&D) consolidated evidence from multiple sources in collaboration with Canadian Armed Forces (CAF) Food Services, Health Services and senior leadership. These sources included organization-wide dietary supplement use surveys, nutrition-related biomarker assessments within the target population, documented practices from the CANSOFCOM Performance Nutrition Program, and consultations with allied SOF nations to benchmark best practices. These data streams were synthesized to make stakeholder recommendations and inform policy requirements.

RESULTS
Findings were compiled and presented to CAF leadership and key stakeholders. Survey results showed high, but inconsistent, supplement use across CANSOFCOM members. Biomarker testing identified the majority of members were outside optimal levels of select key nutrients. These results provided strong justification and helped build stakeholder buy-in for approval and implementation of a standardized, evidence-based CANSOFCOM Dietary Supplement Policy under the guidance of embedded Performance Dietitians.

CONCLUSION
With an embedded Performance Nutrition capability in place and meaningful data sources to support the need for dietary supplementation, it was possible to establish a structured Dietary Supplement Policy to support the provision of evidence-based, third-party tested dietary supplements across CANSOFCOM.

MILITARY IMPACT
The approved Dietary Supplement Policy strengthens Command-wide oversight and, when paired with CANSOFCOM's existing Performance Nutrition capability, enhances operational readiness through targeted dietary supplementation while ensuring SOF personnel receive evidence-based, third-party-tested products aligned with training and mission demands.

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Thematic 2 : Nutrition and sustained physical performance

#46501022
Poster Presentation

Relationship Between Average Energy Balance and Body Composition in Male and Female Recruits During Marine Corps Basic Training

BACKGROUND
Marine Corps Basic Training is a physically demanding environment where recruits often experience significant changes in body composition. Energy balance plays a critical role in shaping these outcomes, yet its relationship to fat and muscle mass changes during training remains unclear.

METHODS
One hundred eighty-two US Marine Corps recruits (122 females, 60 males) from three companies volunteered for a 10-week observational study, with 156 (104 females, 52 males) completing participation. Energy intake was estimated using pre- and post-meal photographs, energy expenditure was tracked via Polar Grit X wearable devices, and body composition was obtained using bioelectrical impedance analysis (InBody 770). Statistical analyses included t-tests to compare energy intake, expenditure, balance, and changes in fat and muscle mass between males and females. Pre- to post-training changes in fat and muscle mass were analyzed with repeated measures ANOVA. The relationship between energy balance, sex, and changes in body composition was assessed using linear regression.

RESULTS
Fat mass significantly decreased from pre- to post-training ($p < .001$), with females losing more fat mass than males ($p = .028$). Skeletal muscle mass increased overall ($p < .001$), with females gaining more muscle than males ($p < .001$). Energy balance significantly predicted changes in fat mass ($R^2 = 0.344$, $p < .001$) and skeletal muscle mass ($R^2 = 0.293$, $p < .001$). In the skeletal muscle model, both energy balance ($p = .011$) and sex ($p < .001$) were significant predictors, and a significant energy balance × sex interaction ($p = .010$) indicated a stronger positive association between energy balance and skeletal muscle mass gain in males compared with females.

CONCLUSION
Marine Corps recruits experienced sustained energy deficits and significant fat loss. Females lost more fat and gained more muscle, despite experiencing larger negative energy balances. Energy balance predicted both fat and skeletal muscle mass changes, with sex-specific patterns.

MILITARY IMPACT
Optimizing nutrition in combination with physical training improves body composition in US Marine Corps recruits, which is important to support performance and recovery during military training.

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Thematic 3 : Psychocognitive readiness for physical performance, resilience, and well-being

Le Grand Salon - Mod: L. Main + N. Kearns

ORAL PRESENTATIONS

Reconnecting to Internal Sensations and Experiences (RISE): Interoception Training for Military Psychological Readiness and Resilience

Effects of Resilience Training Programme (RTP) on RBAF personnel for Deployment of Peacekeeping Mission: United Nations Interim Forces in Lebanon (UNIFIL) with Malaysian Battalion

Closed-loop alpha frequency modulation, through neurofeedback training, enhances attention among healthy individuals with short sleep duration

Performance, stress and wellbeing in basic military training: Impact of resilience, self-efficacy, and mindfulness

Optimized Psychophysiological Breaks Sustain Operational and Live-Fire Performance During 24-h Military Activity

Operational Resilience Training – Preliminary Evaluation Results from Ukrainian Combat Medics Trained in Germany

Investigating the Moderating Effect of Perceived Locus of Control on the Relationship Between Psychological Flexibility and Health-Related Quality of Life

Validation of the Army Individual Monitoring survey (AIMs) to support human performance management

POSTER PRESENTATIONS

The Iron Fist Performance Programme: A Holistic Approach to Health and Performance Optimisation from Brigade to Division.

Latent Cognitive Structure in CANSOFCOM Selection Cohorts: Replication of a Three-Factor Measurement Model

Limitations of Fatigue Risk Performance Modeling for Military Operators

Assessing Cognitive Capabilities in Physically Demanding Occupations

Warfighter Project: Methods to Assess Helmet Configurations on Dismounted Soldier Performance

Influence of marching speed on surveillance performance: Results from a pilot study.

Thematic 3 : Psychocognitive Readiness for Physical Performance

#1000062
Oral Presentation

Reconnecting to Internal Sensations and Experiences (RISE): Interoception Training for Military Psychological Readiness and Resilience

BACKGROUND

Military personnel operate in high-stress, unpredictable environments that demand peak physical and psychological readiness. The ability to accurately recognize, interpret, and adaptively respond to internal cues — a multi-dimensional construct known as interoception — is critical for sustained mission success and overall service member well-being. Deficits in interoception are prevalent within military populations and have been consistently linked to poorer functional performance, reduced emotional regulation capabilities, and a spectrum of negative behavioral and physical health outcomes. To address these critical gaps, the Reconnecting to Internal Sensations and Experiences (RISE) program was developed as a low-burden, highly scalable, and cost-efficient training tool designed to improve interoception and thereby bolster psychological military resilience and readiness.

METHODS

RISE is a self-guided, modular training curriculum structured to restore the crucial feedback loop between cognitive processing and the body's physiological reality. The conceptual framework is organized around four primary thematic domains: First, RISE shifts focus from external physical appearance to instrumental and functional capabilities. Second, RISE reframes emotions as vital evolutionary survival mechanisms that provide actionable biological data through physiological sensations. Third, RISE explores the complex somatic variables of social connection and self-care. Finally, RISE promotes intuitive “fueling” by training participants to accurately distinguish between physiological hunger and emotional dysregulation cues. The intervention integrates evidence-based somatosensory tools, including Progressive Muscle Relaxation (PMR), to elevate baseline body awareness, alongside a specialized operational toolkit designed for in-the-moment cognitive functionality checks.

RESULTS

The efficacy, feasibility, and acceptability of the RISE program have been empirically validated across multiple studies. The initial 2021 pilot study (N = 22 adults at elevated risk for suicide) demonstrated that RISE participation significantly improved interoception, including emotional awareness and self-regulation, while concurrently reducing suicidal ideation. A subsequent large-scale randomized controlled trial (RCT) across multiple military treatment facilities (N = 195) found that RISE was highly acceptable and produced sustained improvements in interoception, as well as reductions multiple behavioral health outcomes (e.g., posttraumatic stress). Lastly, preliminary data from an ongoing prevention-focused study indicate promising outcomes, including measurable reductions in alcohol misuse and suicidality), as well as enhanced coping strategies for navigating military-specific stressors, such as operational workloads and unpredictable schedules.

CONCLUSION

Empirical evidence supports the RISE program as a highly scalable, clinically effective solution for bolstering psychological readiness across diverse military populations. By training service members to systematically reconnect with and interpret their internal physiological cues, the RISE training optimizes interoceptive awareness, thereby conferring significant longitudinal benefits for psychological health, emotional regulation, and functional mission execution. Ongoing strategic efforts are focused on developing a rapid, single-session adaptation specifically tailored for acute deployment scenarios, as well as evaluating the cross-cultural efficacy of RISE by expanding the use of training with allied international military partners.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46813376
Oral Presentation

Effects of Resilience Training Programme (RTP) on RBAF personnel for Deployment of Peacekeeping Mission: United Nations Interim Forces in Lebanon (UNIFIL) with Malaysian Battalion

BACKGROUND

Military readiness traditionally emphasizes physical and operational capability, while psychological readiness remains comparatively underdeveloped within military contexts. Objective: This study examined the effects of a Resilience Training Programme (RTP) on Royal Brunei Armed Forces (RBAF) personnel preparing for deployment under the United Nations Interim Forces in Lebanon (UNIFIL) with the Malaysian Battalion.

METHODS

A multi-phase longitudinal study was conducted among 38 RBAF personnel undergoing deployment for peacekeeping operations with UNIFIL. This abstract reports findings from Phases 1 and 2, with subsequent phases ongoing during redeployment (Phase 3), final post-deployment (Phase 4), and return to unit (Phase 5). Participants underwent a two-week structured programme during pre-deployment (Phase 1) focusing on physical, psychological, and spiritual resilience. Components included stress management, yoga sessions, team-based adventure counselling, arabic language familiarization, and spiritual resilience training. A one-week refresher programme was conducted following deployment (Phase 2). Assessments included the Myers-Briggs Type Indicator (MBTI; Phase 1 only), Emotional Quotient Inventory (EQ-i 2.0), Depression Anxiety Stress Scale (DASS), and Brief Resilience Scale-14 (BRS-14), administered pre- and post-programme to examine longitudinal psychological outcomes. Data were analyzed using paired t-tests.

RESULTS

In Phase 1, 45% (n=17) demonstrated negative changes, 42% (n=16) positive changes, and 12% (n=3) no change across MBTI, DASS, and EQ-i domains. Among the negative changes, 100% (n=17) were slight. No major negative changes were observed. BRS-14 scores increased significantly ($p<0.05$) from 61 to 66 points (mean: 4.36 to 4.71), indicating improved resilience following the programme. However, resilience decreased significantly during deployment to 44.5 points (mean: 3.18).

In Phase 2 (post deployment), psychometric results showed 50% (n=18) positive changes, 28% (n=10) negative changes, and 22% (n=8) no change following the refresher programme. BRS-14 scores increased from 44.5 to 58.6 points (mean: 3.18 to 4.19) post-deployment ($p<0.05$), although levels remained lower than pre-deployment scores.

CONCLUSION

Findings demonstrated variable psychological responses following the pre-deployment resilience programme. Mixed outcomes in Phase 1 may reflect anticipatory operational stress and increased psychological self-awareness prior to deployment. Although resilience improved immediately after training, significant reductions during deployment indicate the impact of operational stress exposure. Following operational deployment, the refresher programme was associated with increased positive responses and reduced negative changes, suggesting improved psychological adaptation after mission exposure. The results indicate that resilience interventions may be more effective after military personnel gain operational experience. However, variability in responses highlights the need for individualized resilience approaches.

MILITARY IMPACT

Pre-deployment resilience programmes may produce variable effects due to anticipatory stress. When combined with post-deployment refresher interventions, resilience training may function as a psychological recalibration mechanism to support recovery, enhance operational readiness, and promote long-term force sustainability.

AUTHORS

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46514471
Oral Presentation

Closed-loop alpha frequency modulation, through neurofeedback training, enhances attention among healthy individuals with short sleep duration

BACKGROUND
Interindividual variability in habitual sleep duration is common in large scale operation, particularly military ones, and does not necessarily reflect unmet physiological sleep needs. Neural markers associated with attention may nevertheless differ as a function of sleep duration. In particular, the individual alpha frequency (IAF), a stable electrophysiological marker linked to attentional efficiency and cognitive performance, may be sensitive to variations in sleep patterns, as alpha oscillatory dynamics are known to reflect arousal regulation and cognitive readiness.

METHODS
A healthy adult population (n = 103) was characterized based on ecologically assessed total sleep time over 11 consecutive days, with a median sleep duration of 6 h. Participants were stratified into short (<6 h) and longer (≥6 h) sleep duration groups. An initial assessment of resting-state electroencephalogram was conducted to evaluate individual theta, alpha, and beta power, as well as IAF and alpha reactivity. Vigilance level was evaluated using a 3-min Psychomotor Vigilance Task (PVT). Sleep-related complaints were assessed with the Pittsburgh Sleep Quality Index (PSQI) and the Epworth Sleepiness Scale. All participants then underwent five sessions of closed-loop neurofeedback training targeting IAF modulation, each lasting 35 minutes and followed by a PVT-3min, conducted from Monday to Friday within the same week.

RESULTS
At the initial assessment, individuals with short sleep duration (n = 51) had reduced IAF and decreased alpha reactivity compared to individuals sleeping ≥ 6 hours (n = 52). Behavioral performance on the PVT was characterized by slower response speed and an increased number of lapses in individuals with short sleep duration (Cohen's d : dspeed = 0.7; dlaspe = 0.68). No differences were observed between the two groups in terms of subjective sleep complaints (PSQI, Epworth). At the end of the closed-loop neurofeedback training, individuals with short sleep duration, who successfully upregulated their IAF, showed a significant improvement in response speed on the PVT (Cohen's d for paired samples: dz = 0.89).

CONCLUSION
A habitually short sleep duration is associated with altered alpha-band dynamics and reduced attention performance, despite similar subjective sleep quality. Closed-loop neurofeedback training targeting individual alpha frequency may be an effective approach to improve attentional performance in healthy individuals with short sleep duration, with potential applications in operational military contexts.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46775359
Oral Presentation

Performance, stress and wellbeing in basic military training: Impact of resilience, self-efficacy, and mindfulness

BACKGROUND
Basic military training is the first phase in soldiers' careers that prepares them for the physical and psychological demands of military service. This initial training thus offers a strategic opportunity to assess how psychological factors influence combat readiness and sustained operational performance – during basic training and in the long-term. Prior research indicates that psychological factors such as individual resilience, self-efficacy, and mindfulness directly impact individual military effectiveness, i. e. performance, stress resilience, and health perception.

METHODS
In a repeated measures design, volunteer military recruits were surveyed on the first day and at the end of basic military training. The following scales were used: Resilience Scale 11, Self-Efficacy Scale - Short Form (ASKU), Acting with Awareness subscale of the Five Facet Mindfulness Questionnaire, Perceived Stress Questionnaire (short scale with 20 items), General Health subscale of the SF-36 Health Survey, and the Andernacher Inventory of Military Performance (AIM). Regression analyses were used to calculate the effect of the psychological factors at the start of basic military training on the outcomes at the end.

RESULTS
Data from 135 male recruits were included in the analyses. Soldiers with higher initial levels of resilience (β = -0.8, R2adj = .09, p = .001), self-efficacy (β = -11.6, R2adj = .11, p < .001), and mindfulness (β = -1.6, R2adj = .08, p = .001) experience significantly less stress upon completing basic military training. They also self-assess their military performance as superior compared to peers (resilience: β = -0.04, R2adj = .13, p < .001; self-efficacy: β = -0.37, R2adj = .05, p = .009; β = -0.06, R2adj = .004, p = .038). Further analysis reveals that self-efficacy increases (W = 1227.5, r = .19, p = .009) during basic military training.

CONCLUSION
Results indicate that while self-efficacy inherently increases during the three months of basic military training in the German army, resilience and mindfulness require dedicated psychological training to fully prepare soldiers for operational challenges.

MILITARY IMPACT
Psychological resilience, self-efficacy, and mindfulness significantly influence soldier performance and stress resilience during basic military training. Incorporating training of these factors into basic military training as well as training at later stages of military careers can enhance soldier adaptability, reduce attrition, and ultimately improve combat performance, thus, delivering a more capable and resilient fighting force.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46792869
Oral Presentation

Operational Resilience Training – Preliminary Evaluation Results from Ukrainian Combat Medics Trained in Germany

BACKGROUND
Military combat is associated with enormous physical and psychological strain. Particularly soldiers involved in frontline casualty recovery and care are continuously exposed to suffering, grief, and death while performing highly complex tasks that put them directly in harm's way. Interventions aimed at increasing individual resilience are, thus, essential to help military medical personnel perform their duties. In keeping with this, armed forces across Europe have implemented a comprehensive Operational Resilience Training (ORT) into the combat medic training of Ukrainian soldiers carried out as part of NATO's support for Ukraine. ORT is a modular training concept developed by Walter Reed Army Institute of Research and Norwegian Armed Forces Joint Medical Services that addresses basic concepts of stress and individual resilience in layman's terms and conveys practical skills for managing combat-associated stress in oneself and others. The aim of the current study was to evaluate two distinct ORT training concepts implemented at German training sites.

METHODS
We examined the effectiveness and acceptance of two ORT variants completed by Ukrainian trainees in Germany: one was limited to a separate, two-day training session preceding combat medic training while the other additionally included practical ORT exercises integrated across the full length of combat medic training. Data from these two groups were compared to a control group that received combat medic training without ORT. Participant surveys included measures of individual resilience, confidence in resilience skills, self-efficacy, and mental wellbeing.

RESULTS
Data from 129 Ukrainian soldiers indicate that the integrated variant of ORT was associated with increased confidence in resilience skills and improved mental wellbeing at the end of combat medic training. In contrast, participants who had received only an isolated two-day ORT training session showed similar end-of-training effects as the control group.

CONCLUSION
We conclude that ORT and similar training interventions aimed at improving individual resilience in military personnel can benefit substantially from close integration with task-oriented aspects of military training.

MILITARY IMPACT
As part of their pre-deployment training, military medical personnel can benefit from a resilience-focused intervention aimed at preparing them for high-stress scenarios associated with combat. This kind of intervention should be closely integrated with occupational and operational aspects of military training.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46808040
Oral Presentation

Investigating the Moderating Effect of Perceived Locus of Control on the Relationship Between Psychological Flexibility and Health-Related Quality of Life

BACKGROUND

Operational demands such as prolonged stress, high load carriage, and environmental exposures heighten Warfighters susceptibility to physical and psychological injuries, influencing perceived health-related quality of life (QoL) and return to duty rates. The presence of injuries contributes to pain-related morbidities which may adversely impact performance. Psychological flexibility (PF), one's ability to adapt and be open to experience, has been shown to improve functional outcomes of those experiencing pain. Similarly, those who believe that their own efforts, not others, determine life events and outcomes (locus of control [LOC]) are more likely to experience lower pain intensity. However, the manner in which these psychological constructs interact to impact the experience of pain and QoL is scarce. The objective of this analysis is to examine perceived LOC as a moderator of the relationship between PF and QoL among U.S. Army Warfighters.

METHODS

Acceptance and Action Questionnaire (AAQ-2; measuring PF), Internality, Powerful Others, and Chance Scale (IPC; measuring LOC) and the Veterans RAND 12 Item Health Survey (VR-12; measuring QoL) surveys were administered to active-duty (N = 578) Warfighters at Ft. Stewart, Georgia. A complete case linear regression of AAQ-2 scores on VR-12 physical (PCS) and mental (MCS) components was conducted to investigate the direct effect of PF on QoL. To investigate interactions between LOC and PF, a moderation analysis between IPC components and AAQ-2 scores was implemented. Johnson-Neyman techniques were used to further decompose interactions.

RESULTS

There were direct negative effects of PF (AAQ-2) on PCS (-.121,$p \leq .05$) and MCS (-.682, $p \leq .05$) QoL. Subsequent analysis demonstrated the internality component of LOC moderated PF's effects for both PCS (.0151, $p \leq .05$) and MCS (.0163, $p \leq .05$). Additionally, the powerful others component of LOC (.0087, $p \leq .05$) and the chance component of LOC (.0117, $p \leq .05$) moderated PF's effects on MCS. For those scoring less than 35.39 on IPC internality there was a significant positive interaction of LOC of PF on PCS ($\beta JN = -.070$, $p \leq .05$). Across IPC valid scoring ranges, there was a significant positive effect of PF on MCS for any interaction model among the three LOC components ($p \leq .05$).

CONCLUSION

Irrespective of LOC, improved relationship between PF and perceived mental health was seen. However, results suggest that 62% of this population would benefit from interventions focusing on strengthening a sense of agency, or internal LOC as a means to bolster PF, which would be expected to also improve perceived physical health.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46832086
Oral Presentation

Validation of the Army Individual Monitoring survey (AIMs) to support human performance management

BACKGROUND
In sport contexts, self-report measures are widely used to monitor athlete responses to the training stimulus and give insights on an athlete's performance readiness. Work had already been undertaken to develop an equivalent measure for use in Defence populations; however, it needed to be validated before it could be considered for use with military personnel. As such, the aim of this study was to validate a brief subjective questionnaire, the Army Individual Monitoring survey (AIMs) for measuring adaptation to training in Army.

METHODS
N=566 Australian Army recruits completed the research questionnaire at a single timepoint, n=6 provided incomplete data and were excluded from the analysis. To protect recruits' anonymity, demographic data were not collected. Time was scheduled into the course program for questionnaire completion to remove time duress on participants. Ethics approval was provided by DSTG Low Risk Ethics Committee (HADS 18-22) and participants provided informed written consent prior to commencing. To facilitate data collection in the training environment questionnaires were completed in pen and paper format provided by the research team. Data analysis was conducted in three sages using Jamovi Statistical Software Version 1.6.23.0. All data was pooled before being randomly allocated to either cohort 1 or cohort 2. Cohort 1 (n=280) was analysed using a series of exploratory factor analyses (EFA), with Oblimin rotation. Items were eliminated if they did not achieve a 0.45 loading on any factor, or cross-loaded on multiple factors. This process was repeated until a clean set of 25 items remained with no cross loading between five factors. A confirmatory principal component factor (PCF) analysis was then conducted using Cohort 2 data (n=280) to validate the questionnaire for use in this population. To assess construct validity, scores on the emergent factors were compared across the recruit groups who scored differentially on the WHO General Health Questionnaire [1] and the Perceived Stress Scale [2].

RESULTS
A clean five-factor solution comprising 25 items (AIMs-25) resulted from the EFA analyses, which was then supported by the PCF. These conceptually distinct factors, with eigen values >1.0 assess perceptions of Fatigue, Soreness, Anger, Stress and Vigour. Subscale internal consistency data will be presented using Cronbach alphas. Ongoing feedback from some Army units indicated a shorter version would assist in higher tempo units and consequently a short-form version (AIMs-10) was also developed. Two items with the highest factor loadings from each of the five factors were retained. Exploratory factor analysis confirmed that the AIMs-10 preserved the original factor structure while reducing response burden.

CONCLUSION
The AIMs-25 is a psychometrically valid survey that could be used to monitor adaptation to training in Army. The AIMs-10 represents a practical alternative for more frequent monitoring however further research is required to validate this short-form version.

MILITARY IMPACT
The AIMs-25 presents as a low-cost scalable measure for monitoring responses to the training stimulus. The AIMs-10 offers a practical alternative for rapid field-based monitoring without compromising conceptual integrity.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46642736
Poster Presentation

The Iron Fist Performance Programme: A Holistic Approach to Health and Performance Optimisation from Brigade to Division.

BACKGROUND

Contemporary land warfare, particularly in high intensity conflict, places exceptional physical, cognitive, and moral demands on soldiers. Traditional approaches to readiness have often treated physical fitness, mental health, and social cohesion as separate domains, limiting their combined impact on operational effectiveness. The Iron Fist Performance Programme was developed within an armoured brigade to deliver a coherent, holistic framework for optimising human performance, strengthening resilience, and generating greater fighting power in preparation for future conflict against peer adversaries. Its success at brigade level led to its adoption by 3 (UK) Division in October 2025, with 31 units now benefiting from a more coherent, evidence informed, and sustainable approach to performance optimisation.

METHODS

The programme adopts a command led, brigade wide model integrating physical, mental, and social fitness within a single performance framework. It is implemented at formation, unit, sub unit, and individual levels, with appointed performance leads coordinating interventions suited to local needs. A cyclical process—goal setting, baseline measurement, analysis, intervention, and adjustment—draws on existing personnel data and actively collected qualitative and behavioural indicators. The approach emphasises leadership behaviours, cultural alignment, positive messaging, and individual responsibility for fitness, ensuring adaptability across both operational and peacetime contexts.

RESULTS

Launched in 2023, the programme engaged approximately 1,600 personnel across the four combat units of the armoured brigade. Units were empowered to assess key determinants of health and identify tailored priorities to enhance performance. This generated a diverse set of initiatives: one unit introduced evening hobby clubs to build social connection; another implemented measures to improve the safety and lived experience of women within a predominantly male regiment; a third prioritised improved sleep and nutrition; and another achieved substantial gains in physical fitness through an innovative redesign of training. At divisional level, brigades now share projects more effectively, information flows seamlessly between researchers, policy makers, and front line operators, and access to resources has improved through strengthened communication networks established by the programme.

CONCLUSION

The Iron Fist Performance Programme shows that holistic human performance optimisation, embedded within unit culture and driven by command leadership, can deliver sustainable improvements in readiness and resilience. By aligning wellbeing with performance, rather than treating them as competing demands, the programme provides a practical model for enhancing soldier effectiveness in demanding operational environments.

MILITARY IMPACT

In high intensity conflict, success relies on cohesive teams capable of sustained physical output, rapid decision making, and moral courage under pressure. The programme strengthens fighting power by optimising the human component of combat capability, improving resilience, and preserving effectiveness over time. Its scalable, adaptable design offers a transferable model for preparing land forces to fight and win in future wars.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46663026
Poster Presentation

Latent Cognitive Structure in CANSOFCOM Selection Cohorts:Replication of a Three-Factor Measurement Model

BACKGROUND
Cognitive performance under sustained stress, time pressure, and complex decision demands is key to effectiveness during special operations assessment. Engle's three-factor framework proposes separate but related domains of attentional control, fluid intelligence, and working memory capacity, which promote adaptive cognition in demanding contexts. The present study evaluated whether this model demonstrates structural validity when applied to CANSOFCOM selection cohorts.

METHODS
Cognitive battery data were collected from consenting candidates across cohorts between 2023 and 2025, yielding a total sample of nearly 300candidates. Descriptive comparisons were conducted across Year and Serial prior to dimensionality analyses. Data suitability for latent modelling was evaluated through sampling adequacy, power considerations, and data integrity screening procedures. Parallel analysis was used to determine the number of latent factors supported by the data. Confirmatory factor analysis tested the Engle three-factor, 11-item structure using cognitive battery scores from the assessment cohorts. A reduced three-factor, nine-indicator (3×3) model was also evaluated.

RESULTS
No meaningful differences in cognitive score distributions were observed by year. When examined by Serial, several test scores differed significantly, including Flanker, Anti-saccade, Number Series, Letter Sets, and PVT performance. Sampling adequacy and power diagnostics supported factor-analytic modelling of the dataset. Data integrity checks indicated acceptable missingness patterns, minimal multicollinearity, and interpretable retained outliers. Parallel analysis supported retention of three latent cognitive factors. Confirmatory factor analysis of the full Engle measurement model showed acceptable model fit: χ^2= 68.62, CFI = 0.920, TLI = 0.880, RMSEA = 0.085 (95% CI [0.062, 0.109]), SRMR = 0.057. Model refinement – using theoretically justified covariance modification indices – improved fit in the full measurement model, yielding robust fit statistics indicative of excellent model fit: robust CFI = 0.974, robust TLI = 0.964, robust RMSEA = 0.045 (95% CI [0.013, 0.070]), SRMR = 0.039, χ^2 = 108.37. The reduced nine-indicator three-factor (3x3) model evidenced weaker but interpretable fit relative to the full Engle model.

CONCLUSION
Results support the structural validity of an Engle-derived, three-factor cognitive measurement model in CANSOFCOM selection cohorts across multiple years. The full measurement model demonstrated stronger fit than the reduced indicator model, implying a slight trade-off between efficiency of the battery's tests and perfect model fit.

MILITARY IMPACT
Establishing stable latent cognitive domains allows for reliable cognitive measurement of key domains during military human-performance assessment contexts. Replication of cognitive-domain structure across cohorts provides a foundation for future work linking latent cognitive abilities to training adaptation and operational performance outcomes.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46700988
Poster Presentation

Limitations of Fatigue Risk Performance Modeling for Military Operators

BACKGROUND

The Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE) model uses information about sleep history and circadian cycles to predict cognitive effectiveness. As SAFTE predictions have been validated against neurobehavioral performance and correlate with the incidence of human factors-related safety accidents, SAFTE data are widely used by military leadership for mission planning and work scheduling. For example, SAFTE models were used to assess the safety of activities planned during a U.S. Navy SEALs high-risk training exercise. However, it is likely that SAFTE predictions based only on sleep and circadian estimates inferred from work/rest schedules are inaccurate. On one Navy watch floor, SAFTE models built using idealized sleep schedules (based on expected work times) predicted a performance effectiveness of 71%; predicted effectiveness fell to 53% when the model used more accurate sleep estimates provided by survey data. Still, sleep surveys are known to overestimate the amount of sleep received in military populations, so the reality of operators' performance is likely to be worse than previously modeled.

METHODS

A total of 98 consecutive days of actigraphy data (Oura Ring) were collected from two operators working a rotating watchbill schedule (days/nights, 12-hr shifts) at a shore-based U.S. Navy command. Four SAFTE models were constructed and compared: two based on known work hours and the actual (actigraphy derived) sleep received by the operators, and two based on survey-derived, group-level sleep estimates and operators' prescribed work schedules.

RESULTS

Despite working the same schedule rotation, operators' effectiveness levels differed significantly both on and off watch (all p's<.001), and the extent to which effectiveness matched predictions from idealized models varied. While the idealized model accurately predicted Sailor A's overall effectiveness (71.7%; no model outcome differences: p=.8), it overestimated actual effectiveness while on watch (70.4%) by 2.6% (p<.001). In contrast, Sailor B's idealized model underestimated overall effectiveness (81.5%) by 5.5% and on-watch effectiveness (83.0%) by 6.1% (all p's<.001).

CONCLUSION

SAFTE model outputs are vulnerable to individual differences in sleep habits despite shared work schedules. While individualized SAFTE models based on actigraphy-derived sleep data should be used to fine-tune work schedules and inform go/no-go decisions about readiness, idealized models based on group-level sleep estimates are likely sufficient to inform schedule management decisions such as the timing/frequency of operations.

MILITARY IMPACT

Performance estimates from SAFTE models are widely used by military leadership across communities including aviation, submarine, surface, and special forces. Accurate SAFTE model outcomes, from models built using sleep inputs at the correct level of individualization, are required to make tradeoff decisions that promote safety and readiness.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46749229
Poster Presentation

Assessing Cognitive Capabilities in Physically Demanding Occupations

BACKGROUND
The development of bona fide physical employment standards (PES) has been central to recruitment, selection and retention of the workforce within physically demanding occupations. However, these PES have predominantly focused on the physical requirements of job-roles, despite the marked increase in cognitive demands associated with technological advancement, complex decision-making, and task performance under stress. At present, no standardised methodological framework exists for assessing whether cognitive capabilities (e.g., decision-making under load, divided attention, working memory under physiological stress) are aligned with occupational demands in these roles. Consequently, the aim of this project is to establish a consensus on the: 1) requirement for developing cognitive capabilities assessments for physically demanding occupations; 2) methodological approaches that could be taken; and 3) anticipated challenges and considerations when developing cognitive capabilities assessments.

METHODS
Researchers, practitioners, and industry experts working with Physically Demanding Occupations, will be asked to complete a qualitative online survey comprising open-ended questions. These detailed responses willbe used to collect data on the 1) requirements for cognitive capability assessments; 2) methods for developing cognitive capability assessments; and 3) challenges and considerations when developing cognitive capability assessments. Data will be analysed using reflexive thematic analysis to identify recurring themes and inform recommendations for future framework development. Where necessary, small-scale focus groups will be conducted to explore emergent themes in greater depth.

RESULTS
To be collected in the lead up to, and during the International Congress on Soldiers' Physical Performance.

CONCLUSION
This work will provide the first structured consensus on the development of cognitive capability assessments for physically demanding occupations and will outline a pragmatic roadmap for future framework development.

MILITARY IMPACT
As with physical employment standards, effective cognitive capabilities assessments could have the potential to enhance operational readiness, optimise workforce capability, mitigate performance-related risk, and reduce associated human and economic costs.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46751063
Poster Presentation

Warfighter Project: Methods to Assess Helmet Configurations on Dismounted Soldier Performance

BACKGROUND

To prepare and endure high-intensity conflicts, helmets are increasingly being used as platforms for mounting additional technologies; despite limited research investigating the performance effects of increasing mass on the head. Future technologies could lead to the realisation of head-up displays and other extended reality technologies. Whilst these advances would extend functionality, they will increase the load carried. Without detailed information on the influence of different helmet configurations, these enhancement technologies could in fact degrade soldier performance. As such, understanding the influence of these technologies on dismounted soldier performance is critical to their survivability and lethality. This interdisciplinary project will investigate the physiological, cognitive, and biomechanical effects of head borne load mass configurations on dismounted soldier performance to understand the potential consequences for survivability and lethality.

METHODS

The project will collect data on 15 participants, all completing with four helmet configurations with moments (measured at the occipital condyle) equivalent to 1) in-service helmet (~80 N□cm), 2) in-service helmet with NVGs retracted (~140 N□cm), 3) in-service helmet with NVGs deployed and a respirator (~220 N□cm), 4) experimental condition with a rearward moment (-30 Ncm). Protocol favourable opinion was received from the UK MOD Research Ethics Committee (2440/MODREC/25). Pre- and post-trial maximal voluntary contractions and isometric holds will be conducted to assess neck flexion and extension fatigue. During the trials, five applied measurements 'blocks' will be undertaken by participants. 1) Load carriage task measuring metabolic cost and collecting 2D motion capture data. 2) An externally valid cognitive task battery using the Dstl IMPACT tool. 3) 3D motion capture of a series of typical dismounted soldiering stances (walking, standing, kneeling, and prone firing positions). 4) A movement between cover task to assess movement speed. 5) A visual search task with eye-tracking data.

Blocks 2-5 are repeated twice; providing a total helmet wear time of approximately 2.5 hours for each condition. Perceptual ratings of physical exertion, mental effort, and comfort will be completed throughout.

RESULTS

Data collection for this research project are currently underway.

CONCLUSION

With the rapidly evolving evolution of technology for the modern soldier, understanding the influence of altering helmet configurations on soldier performance is critical. Using applied interdisciplinary metrics, we hope to be able to define changes in performance with respect to soldier lethality and survivability.

MILITARY IMPACT

The data in this exploratory study, should support future human centred design within this area, along with supporting updates to NATO STANAG 2902 (Non-Ballistic Test Methods and Evaluation Criteria for Combat Helmets), and ultimately dismounted solider performance.

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Thematic 3 : Psychocognitive Readiness for Physical Performance

#46794479
Poster Presentation

Influence of marching speed on surveillance performance: Results from a pilot study.

BACKGROUND
Despite continuous technological advances, foot marches are still an essential military task in modern armies. In military practice, marching is always part of a larger mission. Therefore, the march itself should have as little impact as possible on the physical and cognitive operational readiness required to archive the mission goals. Marching speed is a key factor through which military leaders can influence the amount of exertion associated with a march. In order to make the best possible decision that factors in situational demands, it is necessary to know the extent to which different marching speeds affect operational readiness. The current study is part of the larger research project "Loaded military marching Test: Control and Monitoring of Stress, Exhaustion and Performance Maintenance through Different Marching Speeds". It focuses on the effects of physical stress on cognitive performance during marching at two different speeds (6 km marching distance at 4.5 km/h and 6.0 km/h, respectively).

METHODS
In a within-subjects design (N=21), cognitive performance was compared in two marching conditions (6 km marching distance at 4.5 km/h and 6.0 km/h) on a treadmill with a total load of 32 kg in a climate simulation chamber (25 °C, 60 % relative humidity). In line with the key cognitive requirements during a military march (monitoring the surroundings and identifying potential threats), cognitive performance was operationalized as performance in a surveillance test (response time and percentage of correct responses).

RESULTS
Results show no difference between the two marching conditions after approximately 4.6 km of marching distance. Furthermore, the evaluation of the design using two-factor analysis of variance (distance and marching speed) shows no interaction and no main effect of marching speed.

CONCLUSION
The current study was conducted as part of a larger project to pilot the evaluation of cognitive performance. This accounts for some limitations with respect to the sample size and design that were not tailored to the requirements of the cognitive part of the study. It was not possible to collect data after the full marching distance and the test strength is low (52–53%). However, we pose that regardless of these substantial shortcomings, potential effects of the evaluated marching speeds (4.5 km/h and 6.0 km/h) on surveillance performance that remained undetected in the current study are of no practical relevance to operational readiness, at least for the first 5 km of foot marches.

MILITARY IMPACT
Results of this pilot study indicate that no major restrictions on surveillance performance relevant to the safety of soldiers are to be expected due to a higher marching speed of 6 km/h compared to a marching speed of 4.5 km/h.

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Thematic 4 : From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

Salle Lucienne et André Blin - Mod: K. Friedl + M. Quiquempoix + A. Sedeaud

ORAL PRESENTATIONS

Operationalising Human Performance in Defence: A Framework for Effective Digital Performance Systems

Toward Real-Time Injury Prediction: A Dynamic, Data-Driven Framework

A Computational Blast Overpressure (BOP) Tool as a Complementary Approach to Sensor-Based Monitoring of Repeated Low-Level Blast Exposure During Military Weapon Training

Efficiency in military marching: Study on stress, fatigue and performance maintenance during military foot marches

Feasibility of Combining an Assessment of Mental and Behavioral Health With Wearable Sleep Data Prior to Deployment on a U.S. Navy Ship

POSTER PRESENTATIONS

Far Forward: Prospective Assessment of Operational Acceptability for Next-Generation Biomedical Sensors and Countermeasures

Feasibility of capturing high quality signals for digital biomarkers associated with exertional heat exhaustion

Validity and reliability of wearable heat stress monitors during exercise-induced hyperthermia

Wearable Foot Biomechanics at Scale: Analysis-as-a-Service for Airborne Soldier Training

MoTHuS: Thermophysiological modeling of the soldier. Problem and objective

Improving Skin Temperature Measurement : How to fix

A Secure Federated Knowledge Architecture for Predictive Military Performance in Safety-Critical Operations

Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46652068

Oral Presentation

Operationalising Human Performance in Defence: A Framework for Effective Digital Performance Systems

BACKGROUND

Modern Defence organisations face persistent challenges maximising personnel inflow, generating readiness and sustaining a deployable force, driven by musculoskeletal injury, training attrition, and unavailability. Although Human Performance (HP) frameworks and digital technologies are widely promoted as optimisation solutions, implementation within Defence is often unsuccessful in achieving sustained adoption or operational impact. This gap reflects not a lack of scientific evidence, but systemic failure to translate performance science into scalable, usable capabilities.

METHODS

A narrative synthesis integrated evidence from peer-reviewed research, Defence policy, and applied digital HP implementations across military, elite sport, and high-risk occupations. Evidence was examined to identify recurring barriers implementation, adoption and effectiveness, including cultural resistance, operational constraints, and governance fragmentation, with emphasis on system design, user engagement, organisational integration, and alignment with operational realities.

RESULTS

Across Defence contexts, digital HP initiatives frequently fail long-term due to fragmented ownership, reliance on generic applications or athlete-management systems designed for coach-led environments, poor user engagement, siloed data, and limited integration with organisational decision-making. In contrast, effective implementations, while limited, share common features: role-specific and user-centred design; embedding within existing organisational processes; iterative development informed by stakeholder feedback; prioritisation of behavioural engagement; and translation of multi-domain (i.e., physical, psychological) inputs into simple, decision-relevant outputs rather than increased data volume. These findings informed the development of a whole-system framework for translating HP science and practice into Defence-relevant through-life, digital capability spanning recruitment, training, in-service and transition.

CONCLUSION

Digital HP effectiveness depends less on technological capability or the volume of data collected, rather how evidence is translated into context-specific systems. Digital tools must form part of a coherent, whole-system HP strategy integrating data collection, tailored intervention delivery, engagement mechanisms, governance, leadership ownership, and outcome-oriented analytics with continuous improvement, rather than isolated pilots. Establishing clear design principles and implementation pathways are essential to realise the readiness benefits of digital HP optimisation at scale.

MILITARY IMPACT

As armed forces adapt to high-intensity conflict and increased force-generation demands, digitally enabled HP systems represent a critical capability enabler to support personnel reach across dispersed forces. For example, hybrid physical-digital delivery models provide scalable preparation and performance delivery and assurance where traditional in-person approaches are unsustainable. A whole-system digital HP strategy can strengthen force inflow, reduce preventable attrition, and enhance workforce resilience across the military lifecycle, directly supporting operational effectiveness and force sustainability.

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46735573

Oral Presentation

Toward Real-Time Injury Prediction: A Dynamic, Data-Driven Framework

BACKGROUND

Musculoskeletal injuries (MSKIs) are the leading cause of limited duty and training loss in military populations. Traditional risk assessments rely on a few time-point measures and miss the cumulative, dynamic nature of training load. Continuous wearable monitoring enables objective tracking of external workload and physiological responses during demanding training. This study aimed to develop and validate a real-time injury prediction model using continuous wearable data and implement a decision-support dashboard to identify soldiers at elevated MSKI risk.

METHODS

During a 16-week combat training cycle, 70 soldiers aged 18-22 years were voluntarily recruited and continuously monitored using wearable devices (Garmin Instinct Solar) worn 24/7. Distance-based metrics and heart rate data were collected during both wakefulness and sleep, while injury data were obtained from participants' medical records. A neural network was developed to detect temporal patterns in the data, using fourteen features across four domains: distance, heart rate, sleep, and stress. Each variable was normalized relative to both the individual soldier's and his training team's average to capture deviations at the individual and group levels. Model predictions derived from rolling 4 consecutive-day data windows.

RESULTS

During the monitoring period, 24 soldiers (34%) sustained musculoskeletal injury; most injuries involved the foot and ankle (58.3%), whereas knee and hip injuries each comprised 16.7%, and shin injuries 8.3%. Of the 70 soldiers monitored, 14 were excluded due to insufficient data, leaving 56 for model analysis. The model achieved an overall accuracy of 81.5%, with a precision of 8.6% and a recall of 23.7%. Among injured soldiers with sufficient data for prediction, the model identified 32% as high risk within 21 days prior to their first injury event. For these cases, alerts were generated on average 10.5 days before injury occurrence. In addition, a dashboard was developed to display real-time data and automated alerts for soldiers at elevated risk of MSKI.

CONCLUSION

Continuous wearable monitoring during military training enables early identification of injury risk from longitudinal load data. The model detected a meaningful proportion of musculoskeletal injuries several days before onset. Although overall performance was modest, the findings support continued refinement to enhance predictive performance.

MILITARY IMPACT

Integrating wearable monitoring of internal and external load into training, alongside ongoing refinement of the predictive model, provides actionable lead time for load adjustments that may alter injury risk. A real-time dashboard for commanders and medical staff visualizes training loads and embeds predictive insights into routine decision-making, thereby supporting the translation of research into practice.

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46764926
Oral Presentation

A Computational Blast Overpressure (BOP) Tool as a Complementary Approach to Sensor-Based Monitoring of Repeated Low-Level Blast Exposure During Military Weapon Training

BACKGROUND
Military personnel routinely experience repeated low-level blast exposure during weapon training with large-caliber firearms, shoulder-mounted systems, mortars, howitzers, and breaching charges. Evidence links chronic exposure to cognitive impairments affecting memory and executive function, with weapon training instructors particularly vulnerable. Current monitoring relies primarily on wearable pressure sensors, which face practical limitations including placement variability, limited spatial coverage, and logistical constraints in field environments. Computational modeling can serve as a complement to physical sensing, enabling predictive exposure assessment and dose reconstruction where sensor data may be incomplete.

METHODS
We developed the Blast Overpressure (BOP) Tool, an interactive computational platform for predicting blast exposure during weapon training. The tool comprises a SITE module that reconstructs overpressure zones around weapon systems at defined pressure thresholds (0–2 PSI, 2–4 PSI, >4 PSI), and a SCENE module that generates virtual blast scenes with digital service member models to simulate individual exposure. The tool incorporates validated blast data for sixteen Tier-1 weapon systems (as defined by the NDAA Sec 734 Blast Overpressure Study) spanning shoulder-mounted weapons, rifles, machine guns, howitzers, mortars, and breaching charges. Weapon-specific overpressure characteristics were derived from field sensor data and validated using an inverse solver methodology against independent pencil probe measurements. An Android mobile application was developed for on-site overpressure zone visualization and cumulative exposure estimation across multiple firing stations.

RESULTS
The BOP Tool enables rapid reconstruction of weapon-specific overpressure zones and prediction of cumulative blast dose at various distances and orientations. Validated models show good agreement with field-measured pressure data across all sixteen Tier-1 systems.

The mobile application provides a portable interface for range safety officers to assess exposure without dependence on deployed sensor arrays. When used alongside wearable sensors, the tool creates a layered monitoring framework: computational predictions fill spatial and temporal gaps in sensor coverage, while sensor data validates and refines model predictions.

CONCLUSION
The BOP Tool offers a scalable, complementary approach to sensor-based blast monitoring. By combining physics-based modeling with field-validated weapon data, the tool extends monitoring beyond what sensors alone provide. Desktop and mobile platforms ensure accessibility across planning and field environments.

MILITARY IMPACT
This hybrid paradigm of predictive modeling paired with wearable sensing supports training range safety decisions and development of evidence-based exposure guidelines. Comprehensive blast dose tracking across weapon systems and training scenarios contributes to protecting cognitive readiness in service members, a critical factor for operational effectiveness in high-intensity conflict. Disclaimer: All material has been reviewed by USAMRDC. The opinions contained herein are private views of the authors and are not to be construed as official views of the DoD. Funded by the DoD BIRCO under the MTEC Project Call MTEC-23-06-USAMRDC-MT-103.

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46776357

Oral Presentation

Efficiency in military marching: Study on stress, fatigue and performance maintenance during military foot marches

BACKGROUND

Despite increasing mechanisation of armed forces, military foot marches remain an essential task for soldiers. However, the foot march is only one part of a military mission and must therefore be completed with as little fatigue as possible in order to be mission capable at the destination. Combat load, thermal insulation by clothing and equipment, terrain, climate, distance and speed, in conjunction with personal performance characteristics, determine the individual physiological stress and the resulting fatigue caused by marches. When planning a military operation, most of these parameters can only be controlled to a limited extent. Clothing and equipment, for example, are determined by operational mission requirements. Marching speed, on the other hand, is a factor that can be adjusted by superiors via planning for longer marching times. Own studies with an operational load of 31.5 kg and a stepwise increase of marching speed by 1.5 km*h-1 showed that physiological strain increased disproportionately when speed increased from 4.5 km*h-1 to 6 km*h-1. Aims of this study were to assess physiological and thermophysiological strain associated with these two marching speeds (4.5 km*h-1 and 6 km*h-1) and to determine if there is an operationally relevant difference on fatigue and mission readiness.

METHODS

In a balanced, repeated measured design, heart rates (HR), relative oxygen-uptake (relVO2) and body-core-temperature (BCT) were recorded from 16 healthy male soldiers during marching tests in an environmental simulation chamber (25 °C, 60 % relative humidity). Soldiers wore operational clothing and equipment including ballistic protective vest (total load 32 kg). The marching tests consisted of three phases: i) 6 km marching divided in four 1.5 km distance quartiles (Q1-Q4) at 4.5 km*h-1 and 6 km*h-1, ii) interval test with 5 sprints at 13 km*h-1 with intermittent 15 s break (simulation of a manoeuvre under fire), iii) all-out running test at 13 km*h-1 until complete exhaustion. Phases ii) and iii) served to operationalise the effects of i) with regard to strain, fatigue and mission readiness.

RESULTS

At the end of every quartile, HR (min-1), relVO2 (ml*min-1*kg-1), and BCT (°C) increased significantly less at 4.5 km*h-1 (A) than at 6 km*h-1 (B) with very large effect sizes for all parameters.For Q1 differences were: HR(A) 110 to HR(B) 135 ($t(15) = 10.17$, $p < .001$, Cohen's d 2.54); relVO2(A) 17.3 to relVO2(B) 25.7 ($t(15) = 25.23$, $p < .001$, Cohen's d 6.31); BCT(A) 37.3 to BCT(B) 37.6 ($t(15) = 0.985$, $p < .233$, Cohen's d 0.25). For Q4 the following differences emerged: HR(A) 118 to HR(B) 155 ($t(15) = 11.51$, $p < .001$, Cohen's d 2.88); relVO2(A) 18.4 to relVO2(B) 28.0 ($t(15) = 18.98$, $p < .001$, Cohen's d 4.75); BCT(A) 37.6 to BCT(B) 38.2 ($t(15) = 5.12$, $p < .001$, Cohen's d 1.28). Total time of the running test (phase iii) was significantly higher at 4.5 km*h-1 (A) compared to 6 km*h-1 (B) with a large effect size: A 137 s and B 110 s ($t(15) = 5.05$; $p < .001$, Cohen's d 1.26);

CONCLUSION

Marching with military loads at 6 km*h-1 leads to mission relevant higher physiological and thermophysiological strain compared to 4.5 km*h-1. Furthermore, the higher marching speed reduces soldiers' performance reserves that are needed if they are unexpectedly engaged in action.

MILITARY IMPACT

The findings are intended to form the basis of an application-oriented planning aid for marches which should enable military superiors on site to better plan marches from a preventive medical as well as performance perspective.

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46800715
Oral Presentation

Feasibility of Combining an Assessment of Mental and Behavioral Health With Wearable Sleep Data Prior to Deployment on a U.S. Navy Ship

BACKGROUND
Maintaining optimal readiness and adequate sleep is essential for U.S. Navy Sailors, particularly when preparing for deployment. However, assessment of health and performance factors (e.g., sleep and fatigue, occupational stressors, mental and behavioral health) is challenging in an operational environment. The purpose of the present study was to determine the feasibility and utility of leveraging wearable-assessed sleep with mixed methods assessments of mental and behavioral health in a shipboard environment.

METHODS
Sailors aboard a U.S. Navy ship were monitored in port for 5 weeks prior to deployment. They were asked to complete baseline and post-study questionnaires and three brief weekly questionnaires, and to continuously use a wearable device (Oura Ring, Gen. 3) to collect daily sleep data. Sailors reported on perceived device comfort and usability on the post-study questionnaire. Data yield was calculated as the ratio of number of days in which sleep data were obtained across the entire sample/total number of possible days of sleep data, given the enrolled sample and study duration. Differences in data yield were explored between departments and pay grades using one-way ANOVA.

RESULTS
Participants (n=244, 27±8 years, 14% female) provided 74±27% of possible sleep data throughout the study. Data yield did not differ by ship department, however there was a significant difference by pay grade, with Officers (86±18%), E7-E9 (84±15%), and E5-E6 (77±25%) having higher data yield than their E1-E4 (63±31%) counterparts (ps<.02). On workdays, participants slept 6.3±0.7 h and had 38±17 min of wake after sleep onset. Of participants, 77% found the ring to be “somewhat” or “very” comfortable and 88% reported the ring was “somewhat” or “very” convenient to manage. Survey completion varied across the study duration: baseline=100%, week 1=69%, week 2=50%, week 3=34%, post-study=73%. Additionally, 38 Sailors participated in one of seven focus groups.

CONCLUSION
The data suggest that adequate amounts of daily wearable sleep data can be collected within a mental and behavioral health surveillance capability during a ship’s in-port predeployment phase characterized by high operational tempo, varied schedules, and deployment preparations. Future analyses aim to further categorize associations of sleep data with measures of command climate, stress, and mental health to create actionable recommendations for military personnel and leadership.

MILITARY IMPACT
Sailors serving aboard ships during various phases of a ship’s operational cycle (e.g., while undergoing maintenance, training, predeployment workups, or following deployment) have been overlooked in behavioral health surveillance research. Military personnel serving on ships experience significant stressors and understanding how viable the integration of technology, such as wearables, with other rapid psychological readiness surveillance systems could improve military personnel management ecosystems.

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46661657
Poster Presentation

Far Forward: Prospective Assessment of Operational Acceptability for Next-Generation Biomedical Sensors and Countermeasures

BACKGROUND
Multiple efforts across the U.S. military are developing next-generation tools for monitoring and controlling one's own physiology. However, few consider the acceptability of the tools to the service members who may use them. The Defense Advanced Research Projects Agency ADvanced Acclimation and Protection Tool for Environmental Readiness (ADAPTER) program integrates engineered cells into bioelectronic carriers that the warfighter signals to release therapies to counter the effects of jet lag, shift work, and food poisoning. As part of ADAPTER, we conducted a survey study to assess the interest and acceptability of biomedical sensors and countermeasures, and to provide end-user feedback to inform tool design and development.

METHODS
An anonymous online survey was open to all active duty U.S. service members. The survey assesses preferences for form factor, body placement, and design requirements for safety, security and effectiveness for use of body-connected biomedical tools as countermeasures to the operational health risks of jet lag, shift work, and food poisoning.

RESULTS
A total of 170 service members across all branches contributed (average 13 years of service, 55% officers, 83% male). The most acceptable form factors were external hard wearable (e.g., ring, watch; 84% of respondents rating acceptable), ingestible solution (e.g., liquid, pill; 75%), and external soft wearable (e.g., patch, clothing; 73%). The least acceptable forms were internal implantable (e.g., birth control, heart monitor; 23%), external/internal interface (e.g., insulin pump; 28%), injection (e.g., vaccine, EpiPen; 37%), and internal ingestible (e.g., pill with sensors; 43%). The most acceptable body locations for a fixed-placement device were biceps, triceps, deltoids, and wrist (35-41%). Safety requirements were maximum 23-25% chance of injury/side effects. Top security requirements were multifactor authentication (50%), password (43%), and 24/7 cybersecurity/monitoring (42%).

Top control requirements for deactivation were ability to physically remove the device (72%), physical button or disassembly (47%), and device-connected app (42%). Maintenance requirement for a majority (60-63%) was to recharge/replenish the device a maximum of once a week. Lifespan requirements found a majority (52-58%) would use a device that lasts at least 2 weeks and up to 6 months for jet lag or shift work, and lasts 1 week to 3 months for food poisoning. Effectiveness requirements found 10% of respondents would not use the device for jet lag, 11% would not use for shift work, and 18% would not use for food poisoning. Of those who would use for jet lag, all require circadian alignment (i.e., internal body clock matching the new time zone) within 1 day for travel 2-3 time zones away, with a majority requiring up to 2 days for travel 4-6 time zones away (53-71%), and 3 days for travel 7-12 time zones away (52-65%). For shift work, a majority (59%) accept circadian alignment in up to 2 days. For food poisoning, a majority (61-76%) require symptom relief within 1 hour.

CONCLUSION
Next-generation biomedical sensor/countermeasure tools have varied acceptability but high potential value.

MILITARY IMPACT
A user-centered design approach can inform the development process, enabling innovation and supporting acceptability and utility of technologies for mitigating risks to operational readiness and health.

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46685269

Poster Presentation

Feasibility of capturing high quality signals for digital biomarkers associated with exertional heat exhaustion

BACKGROUND

Predicting exertional heat stroke (EHS) remains challenging due to its complex and heterogeneous pathophysiology and symptom presentation. Although real-time monitoring of vital signs (e.g., heart rate [HR], core temperature [Tc]) is increasingly feasible, large inter-individual variability limits accurate risk stratification. We assessed the feasibility of capturing high quality signals for digital biomarkers associated with exertional heat exhaustion (EHE) and identified optimal sensing sites for obtaining photoplethysmography (PPG) signals.

METHODS

Five healthy males (age: 28 ± 5 yr, body mass index [BMI]: 25.7 ± 1.8, peak oxygen consumption [VO2peak]: 45 ± 4 ml/kg/min) and five healthy females (age: 27 ± 2 yr, BMI: 21.6 ± 2.3, VO2peak: 41 ± 1 ml/kg/min) completed a VO2peak test and two load-carriage trials each. The load-carriage trials involved treadmill walking at 4 $km \cdot h^{-1}$ with 2% inclination to volitional exhaustion (or Tc = 40°C) in an environmental chamber, under warm–humid (WH: 32.2 ± 0.2 °C, 87 ± 2 % RH) and hot–humid (HH: 35.2 ± 0.2 °C, 71 ± 2 % RH) conditions respectively. Rest breaks of approximately 30 min were introduced for every 60 min of load-carriage walk. Continuous measures included ECG-derived HR, Tc, skin temperature (Tsk) and PPG. PPG was recorded from six anatomical sites (forehead, chest, bicep, forearm, thigh, calf) to determine locations yielding robust signals during load-carriage trials. Gait metrics, subjective ratings and speech features were obtained at 10-, 15- and 20-minute intervals respectively during load-carriage trials. Ophthalmological measures (e.g. intraocular pressure, retinal blood flow, etc) were measured before, during rest breaks and at the end of the load-carriage trials.

RESULTS

All ten participants reached volitional EHE in HH in the 2nd walk cycle, whereas only eight did so in WH. One HH trial was terminated by investigators due to observable speech alterations (e.g., slowed/irregular speech, word substitutions, delayed responses). Cardiovascular strain was comparable between conditions, while thermal strain was greater in HH than WH. Among PPG sites, bicep, forearm, and chest produced the cleanest waveforms during exercise. Preliminary observation in gait metrics changes (e.g. chest sway, step length, stance time, stride duration, etc) were observed in 2nd walk cycle as compared to 1st walk cycle for four out of ten participants during HH and/or WH trials. No clear changes were observed in ophthalmological measures to date; several optical datasets remain under processing.

CONCLUSION

These findings demonstrate the feasibility of capturing high quality signals for EHE digital biomarkers discovery, including gait, speech, and ophthalmological measures. Optimal anatomical sites for acquiring high-quality PPG signals were also identified, enabling the capture of cardiovascular changes potentially associated with EHE. Ongoing data collection will expand these multimodal datasets for feature extraction to support development of EHE prediction models using wearable sensing and machine-learning approaches.

MILITARY IMPACT

Characterising multi-modal biomarkers associated with EHE is a critical step toward proactive identification of individuals approaching EHS during training. A robust risk prediction capability could enable early heat-mitigation interventions, reduce medical emergencies, and support safer high-intensity training.

AUTHORS

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46771131

Poster Presentation

Validity and reliability of wearable heat stress monitors during exercise-induced hyperthermia

BACKGROUND

Exertional heat strain is a major risk during physically demanding military training and operations, and accurate monitoring of core body temperature (Tc) is critical for preventing heat-related illness. This study was conducted to evaluate the validity and reliability of commercially available wearable heat stress monitors (HSM) for estimating Tc in healthy adults during exercise-induced hyperthermia and recovery while wearing personal protective clothing.

METHODS

Twenty-one healthy adults (12 male, 9 female; age 40 ± 10 years, height 176 ± 10 cm, body mass 81 ± 14 kg, body mass index 26.0 ± 3.0 kg·m-2, estimated body fat 23.5 ± 6.8 %) completed two identical laboratory trials consisting of treadmill exercise in protective clothing followed by seated recovery. Tc was measured continuously using rectal thermometry (Trec) (criterion) alongside four wearable HSM (Equivital, Kenzen, Zephyr, CORE (arm and chest placement)). Validity was assessed using bias, 95 % limits of agreement (LoA), mean absolute error (MAE), root mean square error (RMSE), Pearson's r, Lin's concordance correlation coefficient (CCC), and the proportion of readings within ± 0.3 °C of Trec. Temperature-dependent error was also examined across 0.5 °C Trec increments. Reliability was assessed using ICC (2,1), test–retest bias, and LoA. The study was approved by the University of Bath Research Ethics Approval Committee (ref: 6265-7509).

RESULTS

All HSM demonstrated poor to moderate agreement (CCC = 0.26–0.85) with wide LoA across both phases. During exercise, Equivital showed the strongest overall performance. During recovery, accuracy deteriorated markedly for all devices, with MAE and RMSE approximately doubling and fewer than one-third of readings falling within ± 0.3 °C of Trec. Temperature-dependent analyses revealed progressive increases in RMSE above ~38.5 °C, peaking during early recovery. When exercise and recovery were combined, Equivital and the CORE devices demonstrated the most favourable performance. Overall reliability was moderate to good (ICC = 0.74–0.81), with lower reproducibility for the arm-mounted devices (Kenzen and CORE-arm).

CONCLUSION

Wearable HSM can track general trends in Tc but lack the accuracy and precision required for individual-level physiological decision-making, particularly at higher Tc and during recovery.

MILITARY IMPACT

In military training and operations, inaccurate estimation of Tc may lead to unsafe decisions regarding heat illness risk. These findings indicate that current wearable HSM should be used with caution for individual monitoring, particularly during recovery and at high core temperatures, and highlight the need for improved algorithms before widespread deployment.

AUTHORS

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46782417

Poster Presentation

Wearable Foot Biomechanics at Scale: Analysis-as-a-Service for Airborne Soldier Training

Airborne operations expose soldiers to extreme biomechanical loads during parachute landings, with forces reaching 8-17 times body weight (LEAP, 1995). Observational studies in both operational and training contexts revealed injury rates of 8.8 and 2.5 per 1000 jumps, respectively, with 15-34% involving the ankle (Knapik et al., 2011a, 2011b, 2014). Lower-extremity injuries during airborne training remain a well-documented challenge despite decades of biomechanical research. While established interventions such as ankle bracing, have demonstrated effectiveness in reducing injury risk, adoption remains inconsistent due to concerns about comfort, perceived mobility restriction, cultural attitudes towards protective equipment, and unintended injury transfer to other joints. This gap between evidence-based injury mitigation and real-world acceptance highlights a broader human-systems integration challenge: effective interventions must not only reduce risk, but also be trusted, usable, and aligned with user perceptions and training culture.

Recent advances in wearable biomechanical sensing including compact inertial measurement units (IMUs) for joint kinematics, portable electromyography (EMG) for muscle activation, and flexible pressure and strain sensors integrated into garments, have expanded opportunities for objective measurement of human movement and loading outside the laboratory (Lobo, 2024). Improvements in sensor miniaturization and fusion now support motion tracking in real-world environments, while EMG and pressure sensing enable characterization of muscle activity and force transmission during dynamic tasks. These capabilities are well suited to evaluating parachute landing fall (PLF) technique, where proper joint sequencing and controlled force distribution are critical but difficult to assess using observational methods alone. However, translating wearable biomechanics into operational field settings introduces substantial challenges.

Many systems assume reliable connectivity or real-time feedback, requiring robust networking, validated analytics across diverse activities, and careful human–system integration to avoid degrading usability and acceptance in demanding environments (Gu, 2026). In response, we employed human-centered design to develop and test a sensor-embedded sock system to support injury risk assessment and training decision-making for airborne soldier training. Rather than treating the sensor as a standalone technology, human factors (HF) principles such as iterative design, stakeholder engagement, and design thinking were used to guide system development.

This work explored an analysis-as-a-service model that uses wearable sensing to provide scalable, objective post-training evaluation of biomechanics across training apparatuses, as well as exploration of fatigue and learning effects and evidence-based training optimization without disrupting the instructor–student dynamic.

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#46811199

Poster Presentation

MoTHuS: Thermophysiological modeling of the soldier. Problem and objective

Heat stress constitutes a major issue in many areas, the military context being no exception. Thermophysiological models have continued to improve and specialize over the last 70 years, however, their relevance and applicability to the soldier remains a question in its own right. Typical parameters such as the duration and intensity of thermal stress, activity, the complexity of military clothing, acclimatization or the level of sports practice are likely to cause difficulty even the most contemporary models.

The long-term goal of the MoTHuS project is to develop a human thermophysiological model dedicated to soldiers. It will start from a historical passive model (like Fiala, Wissler or JOS), from an active component taken from the literature describing the regulatory mechanisms (sweating, shivering, vasodilation). It will then iteratively specialize in the military context thanks to the data acquired via experiments carried out by the IRBA's PEACE unit.

The approach, which will rely on the expertise in multiphysics modeling of the Laboratoire de Mechanics and Energetics of Evry (LMEE), will consist of sensitivity analyzes or even inverse approaches based on measurements in order to calibrate the regulation laws and characterize their dynamics. MoTHuS will make it possible, on long exposures with scripted input parameters, to give, for example, a risk score for a given population of soldiers.

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#47133593

Poster Presentation

Improving Skin Temperature Measurement : How to fix

BACKGROUND

Measuring skin temperature is a challenging task. Accurate measurement depends on the quality of the thermal sensor (sensitivity, resolution, linearity, measurement range, drift, repeatability and reproducibility) as well as the skin-adhesive patch. There are currently a wide variety of adhesive patches with very different physical characteristics (adhesive, air permeability, water permeability, material).Aim of this study: To compare three adhesive dressings (Micropore®, Blenderm®, Urgoderm®) for measuring skin temperature using a thermistor (Captiv TEA®) on human skin in different climatic environments.

METHODS

Measurements were taken on the thigh of two subjects lying at rest. The experimental protocol comprised four successive environments: Ta: 30 °C / RH: 30% (mild and dry), then Ta: 40 °C / RH: 30% (hot and dry), then Ta: 40 °C / RH: 75% (hot and humid), then back to Ta: 30 °C / RH: 30% (temperate dry). Each temperature plateau lasted 20 minutes. Measurements were taken on a 10 cm × 10 cm square of shaved skin. The thermistor was covered completely (experiment 1) or partially (experiment 2) with Micropore®, Blenderm® or Urgoderm®. The centre of the patch was used to measure the reference temperature via thermal imaging (Flir T560® thermal camera). The temperature was recorded continuously (sampling frequency at 32 Hz). The last 2 minutes of each plateau were compared with the temperature reading from the thermal imaging.

RESULTS

The results of Experiment 1 show that skin temperature, as measured by thermal imaging, was 34.68 ± 0.58°C at rest and 38.10 ± 0.14°C during the hot phase. Small deviations are observed depending on the type of mounting, ranging from 0.78 to 0.96 °C in the dry temperate phase, as well as in the hot and humid phase, where deviations range from 0.15 to 0.98 °C. Regarding the comparison with IR, at rest, the experimental results show that the skin temperature measured by a thermistor covered with Blenderm® tape deviates by only -0.25°C, while the version covered with Micropore® deviates by -0.69°C. During the drying phase, we observed temperature differences between the adhesive dressings. Micropore® exhibited the greatest temperature drop, with a steep slope, while Blenderm® exhibited the lowest average slope. Urgoderm® showed an intermediate trend

CONCLUSION

Our results relate to the thermistor/mounting bracket combination. When the probe is covered, we observe that the measurement is only slightly affected by the mounting bracket in mild or hot, dry or humid conditions (overall deviation of less than 0,89°C). The mounting brackets are interchangeable. The measurement error is more likely to be linked to the probe, the sensor or even differences in human skin (topographical variability). The choice will depend on how well the bracket adheres to the skin and on the risk of an allergic reaction. The results of the drying phase suggest that the desorption of water from the fixation medium plays a role. The change in the state of the water stored on the medium likely contributes to the drop in temperature, regardless of skin temperature. Further studies will need to be conducted to understand the influence of the fixation support on exercise and during unstable conditions. The choice of mounting bracket involves striking a balance between the desired measurement quality and the best possible stability. To avoid measurement bias, we recommend selecting a single combination of mounting bracket and temperature sensors through trial and error.

MILITARY IMPACT

During a field study, the quality of the data collection is fundamental to the analysis and interpretation of the results. Our technical findings underscore the importance of exercising the utmost rigour in the selection and subsequent use of the mounting bracket.

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Thematic 4 :
From Measurement to Decision Advantage : Operational Monitoring and Predictive Analytics for Warfighter Health and Performance

#1000059

Poster Presentation

A Secure Federated Knowledge Architecture for Predictive Military Performance in Safety-Critical Operations

BACKGROUND

Military performance can be modeled as the multiplicative interaction of Warfighters × Way of Operating × Means × Operational Context (who acts, how action is carried out, with what means, and under what operational conditions). The model assumes that weakness in one factor can reduce total performance even when the others remain strong. Within this framework, Functional Capacity describes the warfighter's baseline potential to meet task demands, Readiness the currently available share of that potential shaped by sleep, stress, recovery, nutrition, motivation, and cumulative load, and Performance the observable use of readiness in a real task. Current approaches often collect fragmented data without reliably linking pre-task state, task demands, and task outcomes for prediction.

METHODS

We developed a concept-driven reference architecture combining: (1) a holistic military performance model; (2) a knowledge-management layer structuring task requirements, context, performance constructs, and decision logic; and (3) privacy-preserving federated learning for cross-organizational model development without centralizing sensitive data, because only model parameters or updates—not raw local data—need to be shared between sites. The architecture is infrastructure-agnostic and can be implemented through secure environments for sensitive data, AI/data analytics, and high-performance computing (e.g., CSC – IT Center for Science Finland, including the LUMI supercomputer and the LUMI AI Factory) or comparable partner-built capabilities.

RESULTS

The architecture contains five interoperable layers: a conceptual layer defining warfighters, way of operating, means, context, functional capacity, readiness, and performance; a knowledge layer organizing ontologies, task logic, metadata, and context descriptors; a multimodal data layer integrating physiological, movement, sleep/load, environmental, observational, and task-related inputs; a secure computational layer supporting protected data access, data fusion, distributed model training, and scalable AI workflows; and a decision-support layer producing readiness indicators, risk estimates, and task-specific forecasts. The predictive principle is to link holistic pre-task monitoring data and mapped task requirements with observed task performance, enabling AI models to forecast near-term individual or team performance. Real-time data streams can update readiness estimates continuously, allowing forecasts to adapt as conditions change.

CONCLUSION

A secure federated knowledge architecture offers a feasible pathway from fragmented monitoring toward predictive, operationally meaningful support for military performance. By combining holistic concepts, task-specific requirements, secure data governance, federated analytics, and scalable AI infrastructure, the model can transform heterogeneous data into actionable knowledge for decision-making in safety-critical environments.

MILITARY IMPACT

In high-intensity operations, degraded outcomes often arise from interactions between the warfighter, the way of operating, the available means, and the operational context rather than from a single isolated factor. The proposed architecture supports mission-relevant readiness assessment, earlier detection of emerging risk, safer task allocation, and predictive forecasting under fatigue, sleep debt, stress, heat, cold, and cumulative load, while preserving privacy, security, and operational control of sensitive personnel data.

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Thematic 5 : Prevention of musculoskeletal injuries Part I

Salle Moebius - Mod: L. Thefenne + B. Fisher

ORAL PRESENTATIONS

Have We Really Walked the Path? Twenty Years of MSKI Prevention at ICSPP

Achilles Tendon and Myotendinous Macro- and Micro-Morphology, Quality, and Performance Adaptations to 10 Weeks of U.S. Marine Corps Officer Candidate School Training.

Designing and Planning for the Implementation of Injury Prevention and Exercise Programs in Military Environments – An Example from RITE-TRACC

Machine Learning Meets Modifiable Load: A Prevention Framework for Medial Tibial Stress Syndrome

Using Pre-enlistment Functional Testing (PEFT) for Musculoskeletal (MSK) conditions in the Singapore Armed Forces.

Preliminary Evidence for Extracellular Vesicles as Complementary Biomarkers of Training Stress and Early Maldaptive responses in Military Field Training

Co-Design, Implementation and Realistic Evaluation of a Neuromuscular Training Intervention during Royal Navy Officer Training: The Move WELL Warmup

Delivering Musculoskeletal Injury Mitigation Interventions in Military Settings: International Consensus and Next Steps

POSTER PRESENTATIONS

Operationally Ready: The Association Between Motivation, Psychological Needs and Health Behaviours in Defence Personnel

Co-designing Health Interventions to Promote Musculoskeletal Health in Early-Career Royal Navy Personnel

The associations of physical fitness and waist circumference with military service interruptions due to musculoskeletal disorders in a population-based sample of 153 000 young conscripts

Informing the Requirements for Exoskeleton Implementation within UK Defence
Perspective of Musculoskeletal Injury Prevention Strategies

Are U.S. Marine Trainees and Instructors Confident in Injury Prevention Knowledge?

The effectiveness of at-work interventions for supporting work participation in military and law enforcement personnel; a systematic review

Facilitators and barriers in implementing injury prevention interventions in the Royal Netherlands Marechaussee; a qualitative study

Sleep and musculoskeletal injury risk: A prospective cohort study

Extending morning wake-times impacts sleep and fitness in adolescent military recruits

Impact of Intense Physical Activity and Sleep Deprivation on Physiology DuringArduous Military Training.

Prospective Risk Factors for Low Back Pain in Military Personnel: A Systematic Review and Meta-Analysis

Association Between Side Hop Limb Symmetry and Self-Reported Lower Quadrant Musculoskeletal Pain During Military Airborne Training.

Effects of Nicotine Use on Tibial Bone Adaptions in Men During 12 Weeks of Arduous Military Training

Hip Pinning Procedures and Musculoskeletal Injuries During U.S. Army Initial Entry Training and the Future Soldier Preparatory Course

Multidisciplinary Approaches are Needed for Prevention of Musculoskeletal Injuries: Importance of Multidirectional Loading for Skeletal Health

Thematic 5 : Prevention of musculoskeletal injuries

#46410425
Oral Presentation

Have We Really Walked the Path? Twenty Years of MSKI Prevention at ICSPP

BACKGROUND
The ICSPP has been organized for over 20 years and provides a key international forum on soldier physical performance. Musculoskeletal injuries (MSKi) are highly prevalent in military populations and require a full prevention pathway from burden quantification to embedded doctrine. Understanding how ICSPP research has addressed this pathway can identify gaps limiting translation of MSKi science into routine practice.

METHODS.
Across the first six ICSPP editions (2005–2023), 1,574 submitted abstracts were reviewed, of which 1,496 (95%) were categorized into 12 human performance themes. All MSKi-related abstracts (n = 244) were coded into six subdomains: epidemiology and surveillance; risk factors/etiology/screening; intervention trials and prevention methods; barriers/facilitators/policy/compliance; implementation/fidelity/reach/evaluation; and rehabilitation/secondary prevention/treatments/return to duty. These subdomains were mapped to a modified sequence of prevention model adapted from Van Tiggelen et al. (2008), incorporating implementation phases.

RESULTS
Between 2005 and 2023, total ICSPP abstracts increased from 120 to 420 (3.3-fold), while MSKi abstracts rose from 16 to 77 (4.8-fold), with MSKi consistently representing 13–18% of all presentations. On average, 71% of MSKi presentations focused on epidemiology and risk-factor/screening (22% and 49%, respectively), whereas intervention development/testing accounted for 18% and implementation-related work (compliance, policy, implementation, evaluation) for only 8%. Studies addressing barriers, facilitators, and real-world program evaluation remained scarce, although their numbers have started to increase in the most recent ICSPP editions.

CONCLUSION
Over two decades, ICSPP has generated a substantial MSKi evidence base, but research remains concentrated in early stages of the prevention pathway, with comparatively few studies completing the cycle through implementation and evaluation in routine military practice. Despite methodological advances and increased output, there is little indication that MSKi incidence and prevalence in military personnel have decreased meaningfully over this period.

MILITARY IMPACT
To reduce the operational burden of MSKi in high-intensity conflicts, a strategic shift is needed from predominantly observational and risk-factor research toward robust implementation, effectiveness, and policy-focused studies embedded in military training and operational contexts. Prioritizing research on compliance, barriers, facilitators, and real-world program evaluation will help ensure that effective preventive measures are adopted at scale and translated into doctrine, thereby enhancing force readiness and sustainability.

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Thematic 5 : Prevention of musculoskeletal injuries

#46684365
Oral Presentation

Achilles Tendon and Myotendinous Macro- and Micro-Morphology, Quality, and Performance Adaptations to 10 Weeks of U.S. Marine Corps Officer Candidate School Training.

BACKGROUND
U.S. Marine Corps (USMC) Officers demonstrate elevated Achilles tendon (AT) injury rates compared to personnel across other branches. To commission, Candidates must complete 10 weeks of Officer Candidates School (OCS), which may influence myotendinous injury risk before service. However, myotendinous morphology and performance adaptations to such training are unknown. Purpose: Evaluation of myotendinous morphology, collagen fiber organization, and performance using ultrasound, spatial frequency analysis (SFA), and jump/landing forces in USMC Officer Candidates undergoing 10-weeks of OCS.

METHODS
Candidates (n=104 males, age 26.0±3.2 years, BMI 25.9±4.3 kg/m2) were assessed pre-/post- training. B-Mode ultrasonography was used to assess free tendon volume (tV) and echogenicity (tEI, indicative of collagen fiber concentration) of the non-dominant (ND) AT, and physiological cross-sectional area (pCSA, functional muscle architecture) of the medial gastrocnemius. SFA assessed AT collagen fiber spacing (PSFR), organization (P6), and density (Amax). Additionally, countermovement jumps were conducted on bilateral force plates, evaluating jump/landing peak forces, stiffness, and rate of force development (RFD) of the ND limb. Wilcoxon signed-rank test compared pre- to post-OCS differences due to non-normally distributed data, Cohen's d effect sizes were calculated, and α=0.050.

RESULTS
Candidates demonstrated an increase in tV (+4.5%; p<0.001; d=0.28; CI: [-6.07, -1.72], a decrease in tEI (-1.4%; p=0.005; d=0.25; CI: [0.56, 3.18], PSFR (-1.7%; p=0.004; d=0.32; CI: [0.01, 0.06]), and Amax (-2.7%; p=0.006; d=0.35; CI: [0.02, 0.09]) and an increase in P6 (+0.3%; p=0.046; d=0.23; CI: [-0.01, 0.00]); indicating increased intra-tendinous edema and collagen fiber spacing and disorganization. This coincided with reductions in jump peak force (-7.0%; p<0.001; d=0.41; CI: [52.48, 88.22]), stiffness (-9.7%; p<0.001; d=0.26; CI: [124.05, 521.04]), and RFD (-26.7%; p<0.001; d=0.26; CI: [62.64, 467.54]), despite increased medial gastrocnemius pCSA (+6.2%; p=0.001; d=0.36; CI: [-2.40, -0.61]).

CONCLUSION
These findings indicate that degenerative adaptations of the AT (mimicking similar traits found in tendinopathy) were observed in response to 10 weeks of OCS. Additionally, subsequent decrements in force production and development were observed, despite an increase in gastrocnemius pCSA. Together, these findings may suggest an increased risk of myotendinous injury in new Officers post OCS.

MILITARY IMPACT
Given USMC Officers' high prevalence of AT injuries, understanding Candidates' AT structural adaptations can assist in OCS physical training and medical care development to reduce injury risk during OCS and as early-career Officers. Additionally, the use of portable ultrasound for myotendinous evaluation can serve as a cost-effective and widely implementable imaging tool for injury risk detection in the field, before medical diagnosis.

AUTHORS
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Thematic 5 : Prevention of musculoskeletal injuries

#46707292
Oral Presentation

Designing and Planning for the Implementation of Injury Prevention and Exercise Programs in Military Environments – An Example from RITE-TRACC

BACKGROUND
Military training is strenuous, affecting both functional movement and musculoskeletal injury (MSK-I) risk. While MSK-I risk can be reduced through injury prevention and exercise programs (IPEP), these environments are also culturally and structurally unique, elements that must be considered in IPEP design and implementation planning. Here we describe the design and implementation planning of the Tactical 10 IPEP from the RITE-TRACC study at the United States Marine Corps (USMC) School of Infantry-West (SOI-W) that incorporated functional movement targets alongside known cultural and structural barriers to military IPEP participation.

METHODS
Tactical 10 design and implementation planning considered 1) functional movement characteristics affected by infantry training and MSK-I; 2) sentiments from multiple SOI-W and Infantry Training Battalion (ITB) stakeholders, including Combat Instructors (CIs); and 3) known barriers and facilitators to performing IPEPs. Pre- and post-ITB movement assessments included the Functional Movement Screen's In-Line Lunge (ILL), Active Straight Leg Raise (ASLR), and Trunk Stability Push-Up (TSPU); modified Balance Error Scoring System; Landing Error Scoring System-22; and overhead squat and single leg squat. Movement scores were dichotomized based on poor/good performance and Generalized Estimating Equations with logit link function assessed main and interactive effects of time and self-reported MSK-I during ITB on movement scores. Along with movement results, the RE-AIM Framework for Sports Settings, Intervention Mapping, and Integrated Knowledge Translation assisted the study team with Tactical 10 exercise selection and format. The Translating Research into Injury Prevention Practice (TRIPP) framework was used to outline the real-world translation implementation context and facilitate IPEP participation within the SOI-W structure and culture.

RESULTS
Movement screening and MSK-I data were available from 314 male Marines (age=19.7±1.7 yrs). Marines with MSK-I during ITB had 9.3 times the odds (95% CI 3.9-22.5) of scoring poorly/having pain on the ILL post-ITB compared to uninjured Marines ($p<0.001$). Marines with MSK-I during ITB had 3.5 times the odds (95% CI 1.7-7.2) of poor ASLR at either timepoint compared to uninjured Marines ($p=0.001$). Additionally, compared to pre-ITB, all Marines had 2.1 times the odds (95% CI 1.3-4.5) of poor ASLR post-ITB ($p=0.004$) and 3.5 times the odds (95% CI 1.2-9.9) of poor TSPU post-ITB ($p=0.018$). Tactical 10 exercises focused on poor movements identified on the ILL, ASLR, and TSPU and emphasized increasing mobility and flexibility in the upper and lower extremities, core stability, control and balance. To address identified barriers of equipment, time, and to facilitate end-user buy-in, stakeholders agreed the Tactical 10 should include bodyweight exercises, be performed 3-4 times/week for 15-20 minutes in the field during dedicated training and be delivered by ITB CIs following a train-the-trainer method.

CONCLUSION
An implementation science-focused approach was key in the design and implementation planning of an ITB-specific IPEP, the Tactical 10, incorporating functional movement changes, military cultural and structural contexts, and barriers and facilitators to military IPEP participation.

MILITARY IMPACT
IPEP participation can reduce MSK-I risk and improve functional movement. Our approach can serve as a model for other military settings.

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Thematic 5 : Prevention of musculoskeletal injuries

#46788883
Oral Presentation

Machine Learning Meets Modifiable Load: A Prevention Framework for Medial Tibial Stress Syndrome

BACKGROUND
Medial tibial stress syndrome (MTSS) is one of the most prevalent and costly overuse injuries in military training populations and is characterised by diffuse posteromedial tibial bone stress rather than a focal fracture. No consistently effective treatment exists beyond prolonged load reduction. An externally validated machine-learning model has demonstrated high accuracy (>90%) for predicting MTSS risk; however, dominant predictors such as previous MTSS, female sex and limited running experience are largely non-modifiable. This requires identification of modifiable contributors to tibial loading.

METHODS
This study examined whether running load could be decomposed into modifiable components of running technique and whether ground reaction force (GRF) could be estimated using field-deployable methods. Sixteen runners completed seven one-minute trials consisting of preferred running, ±10% speed, ±10% cadence, forefoot strike and rearfoot strike conditions. Vertical ground reaction force (vGRF) and axial tibial acceleration were recorded using an instrumented treadmill and wearable sensors. Machine-learning models were trained to estimate vGRF metrics from kinematic and spatiotemporal inputs.

RESULTS
Reducing running speed by 10% significantly reduced peak tibial acceleration (PTA), vertical average loading rate (VALR) and vertical instantaneous loading rate (VILR) by 13.0%, 10.9% and 9.3%, respectively (η^2 = 0.560). Increasing cadence by 10% reduced PTA, VALR and VILR by 11.5%, 15.6% and 13.5% (η^2 = 0.547). Forefoot strike produced substantially lower loading than rearfoot strike, with reductions of 26.6% for PTA and greater than 68% for VALR and VILR (η^2 = 0.813–0.860). Speed and cadence showed moderate (absolute) correlations with loading metrics (r = 0.27–0.49). Machine-learning models predicted vGRF metrics with coefficients of determination (R^2) ranging from 0.70 to 0.85 and mean absolute percentage errors of 3.4–11%.

CONCLUSION
Tibial loading associated with MTSS is strongly influenced by modifiable aspects of running technique. Small, targeted changes in speed, cadence and foot-strike pattern can meaningfully reduce estimated tibial loads. Machine-learning models enable these changes to be quantified outside laboratory environments, estimating key vertical load metrics with mean average errors of 3.4–10.9%.

MILITARY IMPACT
This work supports a shift from injury treatment to injury prevention by combining accurate risk prediction with modifiable training strategies. Incorporating technique-based load modification into military physical training may reduce MTSS incidence, limit training disruptions and improve personnel availability.

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Thematic 5 : Prevention of musculoskeletal injuries

#46795666
Oral Presentation

Using Pre-enlistment Functional Testing (PEFT) for Musculoskeletal (MSK) conditions in the Singapore Armed Forces.

BACKGROUND

Pre-enlistees in the Singapore Armed Forces (SAF) are assigned appropriate Physical Employment Standards (PES) based on their pre-existing medical conditions. This grading system adopts a diagnosis-based approach, which does not consider an individual's current functional status. Consequently, individuals with prior MSK injuries who have fully regained their premorbid function may still receive a lower PES, thereby reducing the pool of deployable servicemen at enlistment. To address this gap, PEFT was introduced in January 2022. It comprises a battery of region-specific functional tests for each area of injury. These assessments were designed to complement existing medical evaluations, enabling a more accurate determination of PES allocation and appropriate Basic Military Training (BMT) programme. The identified pre-enlistees underwent tests performed by Physiotherapists to evaluate functional movement, joint stability, muscle strength, and range of motion. The inclusion criteria were: a. Previous knee injuries (operated patellar dislocations, or single ligamentous injuries 1-year post –injury or surgery), b. Previous ankle injuries (unstable ankles with recurrent sprains or laxity), c. Spine conditions (chronic back pain with pain score less than 2/10 with normal imaging or degenerative disc disease with minimal symptoms, scoliosis with a Cobb's ankle of 31 to 50 degrees and normal spirometry). Each test was graded across three levels of difficulty, aligned with the higher PES category that the pre-enlistee was being considered for. These levels were designed to reflect the carrying physical demands expected of servicemen upon enlistment. Based on the results, the Physiotherapist provides a recommendation, followed by a holistic review by a Medical Officer who determined the final PES grading.

OBJECTIVE

The objective of the trial was to determine the effectiveness and safety of PEFT. Effectiveness was determined by the rate of completion of BMT by the PEFT candidates, while safety was assessed by the PEFT candidates being downgraded for the same condition to a PES lower than the original intended status.

RESULTS

A total of 331 pre-enlistees were assessed from January 2022 to December 2024. Among them, 227 (68.6%) candidates who passed PEFT were deemed eligible for an upgraded PES. Of these 227, 130 (57.3%) were knee conditions, 88 (38.8%) were ankle conditions, while 9 (4%) were spine conditions. Following final assessment by the Medical Officer, 155 of these candidates had their PES upgraded based on their PEFT. As of the end of December 2024, 36 pre-enlistees were still awaiting enlistment and 29 had been posted to non-SAF services. The remaining 90 individuals were followed through till the end of BMT. Of these, 91.2% (n=82) successfully completed BMT, three did not complete due to an exacerbation of the same MSK condition for which they were originally assessed.

CONCLUSION

PEFT has been shown to be effective in evaluating the functional status of pre-enlistees. Incorporating these assessments can significantly strengthen the medical classification system, enabling more appropriate and productive deployment during their National Service. This study is currently ongoing and aims to include a larger cohort, with outcomes monitored through longitudinal follow-up. A future review may also be conducted to incorporate additional MSK conditions.

AUTHORS

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Thematic 5 : Prevention of musculoskeletal injuries

#46807776
Oral Presentation

Preliminary Evidence for Extracellular Vesicles as Complementary Biomarkers of Training Stress and Early Maladaptive responses in Military Field Training

BACKGROUND
Military field training exposes service members to prolonged physical, mental, and environmental stress with limited recovery, challenging readiness, and increasing musculoskeletal injury (MSKI) risk, the leading cause of lost duty time. Monitoring adaptation in operational settings remains demanding, highlighting the need for stress-response biomarkers. Extracellular vesicles (EVs) are small membrane-bound particles that transport bioactive molecular cargo and carry molecular signatures of their parental cells, reflecting cellular responses to repeated stress exposure. In this context, this study examined circulating EV modulation across an intense Mountain Leader Course (MLC) and its relationships with neuromuscular performance and psychological resilience.

Blood samples were collected from 20 U.S. Marines before, midway through (week 4), and after (week 6) the six-week MLC. EVs were isolated from plasma using size-exclusion chromatography and characterized by nanoparticle tracking analysis, dot-blot EV marker profiling, and untargeted proteomics. Psychological resilience was assessed using the Connor–Davidson Resilience Scale and neuromuscular performance using countermovement jump (CMJ).

RESULTS
EV size, concentration, and canonical surface marker expression (tetraspanins CD63, CD9, CD81) remained stable across training. Body mass and relative CMJ peak power decreased across training (paired t tests: −3.34 kg, 95% CI −4.40 to −2.28, $p < 0.001$; −3.39 W/kg, 95% CI −5.10 to −1.69, $p < 0.001$, respectively). These changes were accompanied by increased levels of the EV-associated stress-related marker HSP60 at mid-training (repeated-measures one-way ANOVA; $p = 0.050$, $\eta p^2 = 0.16$), suggesting activation of stress-response pathways during training. Untargeted proteomics revealed post-training modulation of EV cargo proteins: VCAN (intercellular signaling; $\log_2FC = +1.44$, $p = 0.006$), APOE (lipid transport; $\log_2FC = +0.90$, $p = 0.033$), and SERPINA6 (corticosteroid transport; $\log_2FC = -2.01$, $p = 0.034$).

Proteins showing significant correlations with body mass and CD-RISC (Pearson correlation; $r \geq 0.3$, $p < 0.05$) were analyzed using the Reactome database, and the top-enriched pathways ranked by $-\log_{10}$ (p value) included vesicle-mediated transport, IGF-1 signaling, and inflammatory regulation.

CONCLUSION
During six weeks of MLC, reduced physical performance was paralleled by both increased EV-associated HSP60 expression and specific EV proteomic modulation, while canonical tetraspanins and biophysical properties remained stable, indicating selective modulation of EV phenotype (HSP60) and cargo in response to prolonged training stress. These findings support EVs as complementary biomarkers to neuromuscular performance and psychological resilience measures, capturing early molecular signals associated with maladaptive responses.

MILITARY IMPACT
EV profiling may provide a practical approach to monitoring cumulative training stress, recovery, and adaptive capacity during demanding military courses such as Mountain Leader Course. Integrating EV-based biomarkers with performance and psychological measures may help identify early maladaptive responses associated with increased musculoskeletal injury risk and support strategies to optimize training and readiness.

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Thematic 5 : Prevention of musculoskeletal injuries

#46812497
Oral Presentation

Co-Design, Implementation and Realistic Evaluation of a Neuromuscular Training Intervention during Royal Navy Officer Training: The Move WELL Warmup

BACKGROUND
Musculoskeletal injuries (MSKI) are the leading cause of medical downgrade and discharge from military service. Movement screening at service entry has highlighted poor movement control in Royal Navy (RN) trainees that may increase MSKI risk. A neuromuscular training (NMT) warmup is undertaken prior to RN initial military fitness sessions, aiming to improve trainee movement ability and subsequently reduce MSKI risk. A review of the in-service NMT warmup delivery was initiated following the introduction of the RN Physical Employment Standards (PES) test and changes to entry level fitness requirements. A revised, contextually relevant NMT intervention was implemented into RN Officer Training as service improvement focussing on moving WELL and a process and outcomes evaluation undertaken.

METHODS
A mixed methods approach was used. The warmup content was developed during co-design workshops with Physical Training Instructor (PTI), Exercise Rehabilitation Instructor and Physiotherapist participants (n 16). A training session (theory and practical) established the Officer training intervention implementation approach. Post-implementation realistic evaluation (using RE-AIM) was undertaken involving training delivery observation, pre- and post-implementation movement screening (Hip and Lower Limb Movement Screen) and post-implementation end-user focus groups (n 24). Service entry officer cadet (OC) anthropometric and strength data, captured before and after service improvement activity, enabled between-group analyses.

RESULTS
Following co-design, consensus was reached on the content and delivery approach of the warmup, with coaching points focussing on movement quality. Implementation was undertaken as planned; observations noted delivery of Move WELL coaching points. OCs exposed to the Move WELL warmup during Term-1 (14 weeks) self-reported improved balance and strength and demonstrated improved movement control (n 56,12 female; pre- vs post-; $p \leq 0.001$, $r = 0.54$). In contrast, movement control was poorer in OCs using the previous warmup (n 89, 6 female; pre- vs post-; $p = 0.042$, $r = 0.23$). The Move WELL warmup content and delivery approach were acceptable and feasible for PTI deliverers and OC recipients.

CONCLUSION
This service improvement programme evidenced the feasibility of delivering a NMT warmup intervention that goes beyond “just doing” the exercises; coaching trainees to Move WELL, with good form, was achieved. OCs demonstrated improved movement control, strength, and balance. The content (aligned with RN PES movement patterns) and delivery approach were acceptable to end-users and deliverers.

MILITARY IMPACT
The development of neuromuscular control in foundational movements of early-career personnel has the potential to reduce MSKI risk, support retention and improve Force deployability.

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Thematic 5 : Prevention of musculoskeletal injuries

#47155092
Oral Presentation

Delivering Musculoskeletal Injury Mitigation Interventions in Military Settings: International Consensus and Next Steps

BACKGROUND
Musculoskeletal injuries (MSKI) are the leading cause of medical downgrading and operational attrition across allied military forces. Despite evidence for individual preventive and rehabilitative interventions, system-level implementation at scale remains inconsistent. In September 2024, an international workshop at the 45th ICMM World Congress (Brisbane, Australia) examined the conditions necessary for successful MSKI mitigation programme delivery across three domains: programme design and stakeholder engagement; person engagement during implementation; and metrics for evaluating effectiveness and impact.

METHODS
Military medicine professionals, researchers, and practitioners participated in structured facilitated breakout groups. Participants (n=61) used dot-voting to prioritise implementation enablers within each domain. Findings were synthesised thematically. Subsequent international activity has included initiation of a Five Eyes (FVEY) Whole System Approach (WSA) study assignment and publication of the ROMMIL international MSKI surveillance consensus statement. This session presents the ICMM workshop findings, reports progress from international follow-up initiatives, and invites structured input from ICSPP26 delegates to interrogate and extend the consensus positions.

RESULTS
Military command was identified as the most critical programme design stakeholder (34 votes). Evidence presentation was the highest-ranked initial engagement strategy (26 votes), followed by advisory group formation (19 votes). Force readiness dominated impact metrics (34 votes), ahead of injury surveillance (29 votes) and retention and recruitment (25 votes). A multi-level engagement model -combining top-down command direction with bottom-up practitioner and individual engagement- was considered essential for sustainability. Health and healthcare staff engagement, system flexibility, and sustainable communication mechanisms were identified as critical implementation enablers.

Programmes relying solely on individual-level approaches without Command support and adequate resourcing were consistently identified as at risk of failing to achieve enduring impact.

CONCLUSION
International consensus identified Command engagement, evidence-based dialogue, and multi-level stakeholder involvement as foundational requirements for sustainable MSKI mitigation programmes. The emerging FVEY WSA framework aims to translate these findings into an operational blueprint applicable across allied forces. This session invites ICSPP26 delegates to stress-test these consensus positions against national implementation experiences, identify cross-national dependencies, and contribute to a growing international evidence base.

MILITARY IMPACT
MSKI is the primary driver of medical downgrading across allied forces, directly compromising readiness for high-intensity conflict at a time when all FVEYs nations face workforce capacity challenges. This international programme aims to provide Defence organisations with an evidence-informed, multi-nation implementation framework and shared model to systematically reduce MSKI burden at force level, contributing to ready, resilient, and interoperable fighting forces.

AUTHORS

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Thematic 5 : Prevention of musculoskeletal injuries

#1000064
Poster Presentation

Operationally Ready: The Association Between Motivation, Psychological Needs and Health Behaviours in Defence Personnel

BACKGROUND
Musculoskeletal injuries (MSKI) are a leading cause of medical downgrades and reduced operational effectiveness in the UK military. Initial military training presents a high-risk period for sustaining MSKI but also provides an important opportunity for promoting positive health behaviours to mitigate future MSKI risk. Self-Determination Theory (SDT) proposes that environments supporting the basic psychological needs for autonomy, competence, and relatedness foster autonomous motivation that maintains health behaviours. However, SDT remains underexplored within military contexts characterised by hierarchical structures. This study explored basic psychological need satisfaction and frustration, behavioural regulation and health behaviours in the British Royal Navy.

METHODS
A cross-sectional survey was conducted with 1,591 Royal Navy participants (15.6% female; aged 16–61 years), comprising 941 new recruits, 190 Officer Cadets, and 460 trained personnel. Participants completed the Work Behaviour Regulation Questionnaire and the Basic Psychological Need Satisfaction and Frustration Scale. Health behaviours were assessed using the Defence Health Behaviour Index (assessing sleep quantity and quality, diet quality relative to fruit and vegetable intakes, hydration, physical activity, alcohol consumption and nicotine use) and weight-related health risk was calculated from body weight, height and waist circumference. Linear regression and multivariate analysis of covariance (MANCOVA) were used to explore relationships and group differences.

RESULTS
Supporting basic psychological needs in the workplace was positively associated with autonomous motivation ($P<0.002$), which was also associated with more favourable health behaviours ($\beta=0.119$, $P<0.001$). Frustrating psychological needs were associated with controlled motivation ($P<0.001$) and poorer health behaviours ($\beta=0.082$, $P=0.006$). Trained personnel reported higher weight-related ill-health risk, poorer health behaviours and greater psychological need frustration than trainees ($P<0.001$). Recruit trainees had the highest psychological need satisfaction, but also the greatest introjected and external motivation regulations (i.e., controlled by internal pressures or external rewards). Female and trained personnel exhibited greater weight-related ill-health risk ($OR=0.51$, $P<0.001$).

CONCLUSION
Creating need-supportive military environments may play an important role in fostering autonomous motivation and encouraging positive and sustained health behaviours. Efforts to ensure early-career phases develop self-determined motivation for their work and behaviours could help mitigate MSKI risk and support a thriving defence workforce.

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Thematic 5 : Prevention of musculoskeletal injuries

#46449120
Poster Presentation

Co-designing Health Interventions to Promote Musculoskeletal Health in Early-Career Royal Navy Personnel

BACKGROUND
Musculoskeletal (MSK) injuries remain a leading cause of training delays, healthcare burden and medical discharges from the Royal Navy (RN). Suboptimal health behaviours among sailors (including physical activity, diet, sleep, alcohol consumption, and nicotine use) increase injury risk. Supportive work environments and targeted digital health (eHealth) interventions offer scalable solutions to support behaviour change and promote MSK health. Historically, interventions have been designed for rather than with personnel, where intervention effectiveness is improved through tailoring to participant needs. Moreover, effectiveness in military contexts depends on alignment with the unique workplace, end-users' lived experiences, and operational constraints. This study aimed to co-design acceptable and contextually relevant health interventions to promote MSK health.

METHODS
Following the Person-Based Approach framework, focus groups were conducted with early-career RN personnel (n=56). Health behaviour challenges, intervention preferences and acceptable delivery modes were explored. Data were analysed using reflexive thematic analysis, and themes were mapped to the COM-B model.

RESULTS
Personnel identified early military training as a critical opportunity to establish good health behaviours. Barriers to MSK health reflected deficits in capability, including limited health and fitness education; reduced opportunity due to time constraints, inconsistent access to facilities or equipment, and variable fitness accountability at individual and organisational levels. Facilitators to MSK health included enhanced capability through access to clear, credible health and fitness education and increased opportunity via supportive environments, food provision, self-catering, practitioner access, and peer support. Participants favoured a hybrid intervention combining environmental improvements with digital technology. Desired eHealth features included tailored evidence-based health and fitness information, peer support, and wearable fitness monitor integration to support goal setting, self-monitoring, and sustained engagement through intrinsic motivation.

CONCLUSION
This study demonstrated the importance of designing health interventions with personnel to reflect their lived experiences, operational realities, and motivational needs. Early career stages represent an important opportunity to establish health behaviours that support healthy military careers. User-centred digital interventions with supportive workplaces may be effective for injury prevention and performance improvement.

MILITARY IMPACT
Engaging personnel in co-design provides actionable insights to embedding health behaviour change interventions within military workplaces; enhancing physical readiness, reducing injury risk, and supporting career-long health and performance. These findings have informed the development of an RN eHealth capability to support MSK good health.

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Thematic 5 : Prevention of musculoskeletal injuries

#46651155
Poster Presentation

The associations of physical fitness and waist circumference with military service interruptions due to musculoskeletal disorders in a population-based sample of 153 000 young conscripts

BACKGROUND
Musculoskeletal disorders represent a significant health concern in physically demanding military environments. Moreover, obesity and poor physical fitness have become increasingly common among young adults, complicating planning and implementation of military training. We investigated how cardiorespiratory and muscular fitness and waist circumference influence the incidence of interruptions in military service due to musculoskeletal disorders among young men.

METHODS
The present study included data from 152 867 men (mean age 19.7 ± 1.1 years) who performed compulsory military service in Finland. At the beginning of service, each conscript completed a 12-minute running test, a muscular fitness assessment (including push-ups, sit-ups, and standing long jump), and a waist circumference measurement. These data were linked to diagnoses of musculoskeletal disorders that led to interruption of military service, and individuals with such diagnoses were compared with those who completed the service. An extended Cox regression model was applied to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) for the risk of service interruption due to MSDs. The proportional hazards assumption was assessed using Schoenfeld residuals.

RESULTS
Of the 152 867 young men, 2011 (1.3%) interrupted service due to musculoskeletal disorders. Conscripts who interrupted had a larger waist circumference (86.3 cm (12.0) vs. 84.7 cm (10.6), p<0.001) and lower 12-minute running test (2280 m (437) vs. 2415 m (383), p<0.001) and muscular fitness index results (108.8 (27.0) vs. 112.4 (26.6), p<0.001) compared with those who completed service. In adjusted Cox regression analyses, larger waist circumference increased the hazard of interruption at the 1-month time point (≥100 cm vs <80 cm: HR 2.01, 95% CI 1.62–2.49), whereas higher 12-minute running and muscular fitness index test results were protective in a dose-dependent manner (≥3000 m vs <2200 m: HR 5.16, 95% CI 3.71–7.16 and ≥125 vs <80: HR 2.65, 95% CI 2.08–3.37). The risk was greatest during the early phase of service and declined over time.

CONCLUSION
This population-based study identified that higher physical fitness and lower waist circumference were associated with lower likelihood for interruption of compulsory military service due to musculoskeletal disorders. Furthermore, the risk was also substantially elevated among young men with central obesity, with the greatest likelihood of service interruption observed at the onset of military training.

MILITARY IMPACT
Enhancing physical fitness and preventing obesity represent important preventive strategies to avoid military service interruptions due to musculoskeletal disorders. In addition, training load modification for individuals with increased risk for service interruption is recommended, especially in the early phases of military service.

AUTHORS

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Thematic 5 : Prevention of musculoskeletal injuries

#46652349
Poster Presentation

Informing the Requirements for Exoskeleton Implementation within UK Defence

BACKGROUND
An exoskeleton (EXO) is a wearable device designed to reduce musculoskeletal strain by offloading the physical and/or mechanical demand from the wearer's muscles and joints. The Defence Science and Technology Laboratory (Dstl) Human Augmentation (HA) Project identified EXOs as a technology that could augment military activities. Manual handling tasks are performed routinely across Defence. They are highly structured and less prone to variability caused by environmental changes, making them an ideal use case for EXOs. Currently EXO technology and research is commercially focussed and not optimised for UK Defence. Therefore, Dstl has implemented a human centred design approach which aims to understand where EXOs provide benefit and recommend design requirements to augment performance. Medium Girder Bridge (MGB) building performed by the Royal Engineers was identified as an exemplar manual handling use case to situate this work.

METHODS
Three distinct pieces of work were conducted in parallel: - MGB building task analysis – Field observation of MGB build during a training course. - HA Early Human Factors Analysis (EHFA) of EXOs in MGB - Identification of the human considerations to be addressed in the development of an EXO. - Scoping review of EXOs for manual handling – Review of manual handling EXO research published between June 2021 – August 2025.

RESULTS
Task analysis – MGB building presents considerable physical demand for Royal Engineers. Team-based lifts regularly expose individuals to masses of up to 50 kg causing severe strain for the back, shoulders and arms across multiple lifting cycles. EHFA – EXOs are expected to provide the most value when considering multiple bridge builds rather than individual builds. The operational benefits presented by EXOs include enhanced lethality, increased survivability and increased operational capacity. However, they will only be realised with further development of EXOs.

Scoping review – There were 82 studies included in the review highlighting the considerable developments in this area. Passive back support EXOs show the most promise for performance augmentation. However, this evidence base is small with most research focusing on injury prevention rather than performance augmentation, although military-relevant research has shown these paradigms may be synergistic rather than exclusive.

CONCLUSION
MGB building involves a high physical burden and high movement complexity compared to commercial manual handling tasks. EXOs could provide considerable operational advantage to UK Defence, however current EXOs do not address the unique task demands of MGB building. Future research should pursue systematic lab and field-based activities with mechanistic and performance measures to ensure EXOs are ready for UK Defence.

MILITARY IMPACT
The present work provides evidence to support decision making for the exploitation and implementation of EXOs within UK Defence. Combined, the outputs will be used to develop EXOs which meet UK Defence needs. In turn ensuring the potential operational benefits are capitalised.

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Thematic 5 : Prevention of musculoskeletal injuries

#46705890
Poster Presentation

Perspective of Musculoskeletal Injury Prevention Strategies

BACKGROUND

Musculoskeletal injury (MSKI) is the leading threat to U.S. Warfighter readiness, accounting for 55% of non-deployability and medical profiles. MSKI affects over 50% of Warfighters, drives more than 1 million medical encounters and ~10 million limited-duty days annually, and accounts for 81.1% of medical evacuations during OIF/OEF, which significantly degrades unit cohesion and combat power.

METHODS

Largely conducted via the U.S. Defense Health Agency's MSKI Research Program, this effort uses a science and technology (S&T) portfolio analysis approach rather than primary data collection. An internal review of funded MSKI prevention projects across various funding mechanisms to characterize research distribution, prevention focus (primary, secondary, tertiary), and stage of research (basic through translational). These methods will provide a program-level overview of MSKI injury prevention within the DHA research enterprise, focusing on investment strategy, capability alignment, and translational impact across the continuum of care.

RESULTS

Across multiple Service branches, training pipelines, and operational communities, data from observational studies, prospective cohorts, biomechanical modeling, and program evaluations demonstrate that musculoskeletal injury (MSKI) risk is multifactorial and quantifiable. Analyses across entry-level training, aviation/airborne, and special operations populations characterized injury risk across biomechanical (landing forces, load carriage, spinal vibration), physiological (iron status, hormonal profiles, biomarkers of oxidative stress), cognitive, and environmental domains. Cohort-based and longitudinal surveillance frameworks enabled systematic injury capture, and comparison of injury burden across training phases and occupational specialties. Individualized risk assessment approaches, including warfighter-specific modeling and integrated biomarker and exposure profiling, supported stratification of injury risk by sex, occupation, and training exposure.

CONCLUSION

These results indicate that MSKI prevention strategies grounded in cohort-based analysis, continuous surveillance, and evaluation frameworks can reduce injury burden and inform scalable Defense Health Agency–wide injury mitigation to sustain readiness and operational lethality. A comprehensive MSKI strategy must address both injury prevalence and individual vulnerabilities, including sex, occupation, sleep, nutrition, and psychological factors.

MILITARY IMPACT

In future multi-domain operations, poor prevention and injury risk mitigation will drive evacuations, erode readiness, and reduce unit lethality.

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Thematic 5 : Prevention of musculoskeletal injuries

#46725755
Poster Presentation

Are U.S. Marine Trainees and Instructors Confident in Injury Prevention Knowledge?

BACKGROUND
Musculoskeletal injuries (MSK-I) hinder military readiness, causing lost duty time and early separation. While early prevention education can reduce MSK-I risk, it is unknown if instructors or trainees believe they possess appropriate MSK-I prevention knowledge. During a larger study in the U.S. Marine Corps (USMC) entry-level training pipeline at Marine Corps Recruit Depot-San Diego (MCRD-SD) and School of Infantry-West (SOI-W), we evaluated confidence in self-perceived knowledge of MSK-I prevention methods.

METHODS
Upon graduation from their respective training courses, recruits at MCRD-SD and students at SOI-W completed a survey assessing demographics and knowledge, attitudes and beliefs about MSK-I and MSK-I prevention.Drill Instructors (DIs) at MCRD-SD and Combat Instructors (CIs) at SOI-W completed a similar survey. Regarding self-perceived MSK-I prevention knowledge, respondents rated their agreement with the statement “I am confident I know appropriate exercises and/or training methods to reduce my risk of MSK-I” on a 5-point Likert-style scale (strongly agree to strongly disagree). Responses were collapsed into “agree,” “disagree,” and “neutral” for analysis. Group differences in confidence ratings were analyzed via Kruskal-Wallis H tests followed by Dunn’s post hoc comparisons with Bonferroni-adjusted significance ($p < 0.008$).

RESULTS
The survey was completed by 471 MCRD-SD recruits (M=86%, F=14%, age=19.8±2.1 yrs), 351 SOI-W students (n=351, M=99%, F=1%, age=20.1±2.1 yrs), 78 DIs (M=87%, F=13%, age=25.0±2.5 yrs) and 25 CIs (M=100%, age=26.2±3.4 yrs). Most were high-school educated (recruits: 78%; students: 80%; DIs: 62%; CIs: 60%) and were either White/Caucasian (recruits: 36%; students: 44%; DIs: 28%; CIs: 72%) or Hispanic/Latino (recruits: 36%; students: 33%; DIs: 45%; CIs: 20%). DIs and CIs primarily held the rank of Sergeant (E5) (DIs: 88%; CIs: 60%). Confidence in self-perceived knowledge of MSK-I prevention methods differed across groups ($X2(3)=21.35$, $p < 0.001$). Recruits exhibited lower confidence (agree: 50%; neutral: 30%; disagree: 21%) compared to DIs (agree: 73%; neutral: 18%; disagree: 9%) ($z=-3.98$, $p<0.001$) and students (agree: 57%; neutral: 35%; disagree: 9% ($z=-3.13$, $p=0.002$). CIs (agree: 60%; neutral: 32%; disagree: 8%) did not differ from the DIs or recruit or student groups ($p > 0.008$).

CONCLUSION
A significant "confidence gap" in self-perceived knowledge of MSK-I prevention methods was observed in recruits in basic training at MCRD-SD, highlighting an early intervention window for targeted MSK-I prevention education. The greater confidence reported by SOI-W students compared to MCRD-SD recruits suggests a cumulative learning effect across the training pipeline, yet underscores the need for a standardized, evidence-based curricula. While high self-perceived knowledge among DIs and CIs can facilitate education, the preventative value of this instruction depends on alignment with evidence-based MSK-I prevention methods. Future research should evaluate the instructors’ MSK-I prevention methods and the implementation of MSK-I education during military training.

MILITARY IMPACT
Enhancing MSK-I prevention literacy may reduce MSK-I related training attrition and separation. Early interventions may address knowledge gaps, promote a culture of proactive MSK-I risk mitigation, and improve force readiness and retention.

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Thematic 5 : Prevention of musculoskeletal injuries

#46740315
Poster Presentation

The effectiveness of at-work interventions for supporting work participation in military and law enforcement personnel; a systematic review

BACKGROUND
Armed forces and law enforcement personnel face high, often unchanging occupational demands. As a result, they are prone to adverse health, which can negatively affect their work participation. Reduced work participation in this population can have detrimental consequences for military and law enforcement readiness. This systematic review provides an overview of the literature on in-work interventions to promote work participation among these populations.

METHODS
We systematically searched six databases for studies investigating the effect of an at-work intervention on work participation in military and law enforcement populations. We excluded studies involving veterans or retired law enforcement officers. We assessed the risk of bias for each study that met our inclusion criteria and synthesised the findings.

RESULTS
After screening 7014 studies, this systematic review included 14 papers reporting on 13 studies. The 13 interventions studied in the included studies can be broadly classified into four categories: 6 exercise programmes, 1 rehabilitation programme, 3 orthotic devices, and 3 multidisciplinary interventions. A multidisciplinary intervention to prevent low back pain was the only low-risk-of-bias intervention that was effective in improving work participation (adjusted hazard ratio = 0.42, 95% CI = 0.18–0.94, p = 0.035).

CONCLUSION
This systematic review identified 13 studies of interventions to improve work participation in military and law enforcement populations, of which one was effective. Given the operational importance of keeping personnel fit for duty, future trials should systematically include work participation as a primary or secondary outcome measure.

MILITARY IMPACT
To gain a comprehensive understanding of military readiness, future studies should include work participation as an outcome measure when assessing the effectiveness of interventions for military personnel.

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Thematic 5 : Prevention of musculoskeletal injuries

#46740429
Poster Presentation

Facilitators and barriers in implementing injury prevention interventions in the Royal Netherlands Marechaussee; a qualitative study

BACKGROUND
Musculoskeletal injuries are highly prevalent among military personnel, and numerous studies have demonstrated the effectiveness of preventive interventions under controlled trial conditions. Nevertheless, these injuries remain the leading cause of morbidity in military organisations, imposing substantial financial costs and potentially compromising operational readiness. To achieve lasting impact, preventive strategies must move beyond efficacy testing and be sustainably implemented and embedded within routine military practice. This study described the facilitators and barriers to implementing injury-prevention training programmes within the Royal Netherlands Marechaussee.

METHODS
This was a qualitative study of 36 purposively sampled members of the Royal Netherlands Marechaussee. We based our methodology on grounded theory and emergent design principles. We used a semi-structured interview guide to conduct interviews and focus groups with participants until data saturation was reached. All interviews and focus groups were recorded and transcribed verbatim, and the authors conducted a thematic analysis using open, axial, and selective coding.

RESULTS
The analysis revealed facilitators and barriers across one overarching theme and several subthemes regarding the implementation of injury prevention training programmes at the Royal Netherlands Marechaussee. The overarching theme is responsibility for implementation, and the six core themes cover the following topics: commitment, motivation, timing considerations, the programme, facilities, and coaching.

CONCLUSION
This qualitative study revealed several facilitators and barriers to implementing injury prevention training programmes in a military population.

MILITARY IMPACT
To support military readiness, it is imperative that efficacious injury prevention programmes are sustainably implemented in military organisations. To support implementation, facilitators and barriers should be described explicitly. The current findings will guide the implementation of injury prevention programmes at the Royal Netherlands Marechaussee.

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Thematic 5 : Prevention of musculoskeletal injuries

#46771880
Poster Presentation

Sleep and musculoskeletal injury risk: A prospective cohort study

BACKGROUND
Poor sleep is prevalent in athletes and soldiers, yet prospective evidence linking sleep with musculoskeletal injury (MSKI) risk is limited. We therefore prospectively examined the association between sleep and MSKI in young adults undertaking 12-weeks of basic training.

METHODS
970 new recruits completed baseline measures of civilian-life sleep duration and quality using the Pittsburgh Sleep Quality Index (PSQI). Sleep was reassessed in training weeks 5 and 12 using PSQI and objective actigraphy. Physician determined MSKI during training, classified as traumatic or overuse, was extracted from medical records. Logistic regression models examined the association between sleep and MSKI and were adjusted for BMI, smoking, season, training exposure and aerobic fitness.

RESULTS
An MSKI was suffered by 208 recruits, of which half were traumatic. 93% of MSKIs resulted in time lost from training and MSKI was associated with course non-completion (OR=1.7, 95% CI 1.2–2.3, P < 0.01). Sleep duration (PSQI) decreased from 8.0 ± 1.5 h in civilian life to 6.3 ± 0.9 h during the first month of training and 6.6 ± 1.1 during the last month of training. Despite the reductions in sleep duration, global PSQI score was unchanged (range of means: 4.9-5.1) due to reduced sleep latency and increased efficiency; but daytime dysfunction worsened. Short civilian-life sleep duration (<6h/day) increased risk, particularly for traumatic MSKIs occurring in the first month of training (OR=2.29, 95% CI 1.1–4.7, P < 0.05); though poor sleep quality before training did not. Poor sleep quality in the first month of training doubled the risk of MSKI after week-5. Those with the poorest sleep quality reported poorer sleep latency, efficiency, daytime dysfunction and had shorter actigraphy-derived sleep duration. The risk of MSKI was not increased in the 21% of participants whose global PSQI score improved during training (P > 0.05).

CONCLUSION
Poor sleep quality and short sleep duration were independently associated with increased MSKI risk, which was particularly increased for traumatic injuries. These injuries occurred over a period of 12 weeks in a uniquely controlled environmental with high levels of physical exertion. Improved sleep quality during training was associated with protection against MSKI risk. Poor sleep is a modifiable risk factor for musculoskeletal injury highlighting the importance of good sleep hygiene and sleep opportunity during periods of high physical activity.

MILITARY IMPACT
These findings identify poor sleep as a modifiable risk factor for MSKI in initial training and suggest that improvements in sleep quality may potentially confer protection against injury. Training providers should consider incorporating sleep health strategies into military training programmes. Improving sleep opportunity, reducing avoidable sleep disruption, and integrating sleep education before and during recruit training could reduce injury rates, minimise lost training days, and improve training completion.

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Thematic 5 : Prevention of musculoskeletal injuries

#46772959
Poster Presentation

Extending morning wake-times impacts sleep and fitness in adolescent military recruits

BACKGROUND
Adolescent recruits in military training often experience chronic sleep restriction, which may impair recovery, adaptation, and health. This study evaluated the impact of extending morning wake-times on sleep, well-being, and physical performance during basic training.

METHODS
A two-arm, clustered, parallel trial was conducted with 701 Junior Soldiers (age 16.5 ± 0.5 yrs). From weeks 11–40, the experimental group (EXP; n = 337) received a 90-min later wake-time (07:00), while controls (CON; n = 364) maintained standard wake-time (05:30). Lights out was 22:00 for both groups. Sleep was assessed via actigraphy (subsample) and self-report; surveys captured sleep quality, stress, and sleepiness. Role Fitness Tests (2-km run, mid-thigh pull [MTP], medicine ball throw [MBT]) were completed at baseline and week 40. Linear mixed models examined group differences and predictors of change in fitness.

RESULTS
EXP obtained ~1 h more nightly sleep (07:08 ± 0:45 h vs. 06:08 ± 0:42 h) and reported improved sleep quality (12% fewer reporting poor sleep), reduced excessive sleepiness (22% reduction), and lower stress (18% reduction). Both groups improved aerobic fitness similarly, but EXP gained significantly more lower-body strength (+5 kg MTP, $p = 0.004$), while CON improved upper-body power more (+12 cm MBT, $p = 0.002$). Baseline fitness strongly predicted change across all tests.

CONCLUSION
Extending wake-times during training improved sleep duration, quality, and perceived well-being, and enhanced strength adaptation without compromising aerobic fitness. Enhanced strength adaptation in the extended sleep group suggests that better recovery supports physiological development, whereas power and endurance remain dependent on specific training stimuli. Wearable monitoring proved feasible and informative in this adolescent military population.

MILITARY IMPACT
Adjusting training schedules to allow extended wake-times offers a scalable, low-cost strategy to mitigate sleep restriction: a common challenge in high-intensity military training and operational preparation. By improving recovery, reducing stress, and supporting strength development, modest schedule changes may enhance training resilience and reduce injury or attrition risk in young recruits. Such approaches can strengthen force readiness by improving health and performance without requiring additional training time or resources.

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Thematic 5 : Prevention of musculoskeletal injuries

#46784077
Poster Presentation

Impact of Intense Physical Activity and Sleep Deprivation on Physiology During Arduous Military Training.

BACKGROUND
Royal Marines Officer (RMO) training prepares civilians for challenging frontline leadership roles. It involves intense physical activity (PA) and limited recovery—key factors in its prolonged, demanding nature. Such training carries a high risk of bone injuries, influenced by PA and recovery habits that may impact bone turnover and injury susceptibility. This study examined the PA, recovery behaviours, and bone metabolism of RMO trainees to betterunderstand injury risk.

METHODS
Nineteen male trainees provided blood samples at weeks 1, 7 and 12 of RMO training. Changes in interleukin-6 (IL-6), procollagen type 1 N-terminal propeptide (P1NP), and bone-specific C-terminal telopeptide of type 1 collagen (β-CTx) were assessed using enzyme linked immunosorbent assay (ELISA) methods. Additionally, participants were equipped with an accelerometery device (GENEActiv) with a custom macro to quantify the duration (in minutes) of moderate and vigorous physical activity (MVPA) and sleep respectively. Descriptive statistics were calculated on a daily and weekly basis, as well as for specific training periods relevant to the syllabus design. Differences between time points were analysed using paired samples t-tests ($P \leq 0.05$). Ethical approval: 1035/MODREC/20.

RESULTS
β-CTx increased between week 1 and week 7 (from 1409 ± 827 pg/mL to 1934 ± 1045 pg/mL [+37%; $P < 0.001$])) with elevated levels persisting until week 12 (1853 ± 975 pg/mL [+32%; $P = 0.045$]). P1NP was above the normal male reference while IL-6 was at or below the assays lower limit of detection for all time points analysed (<2.0 pg/mL, however, no significant changes were detected. Daily MVPA ranged between 186 ± 101 and 414 ± 46mins/day with sleep duration ranging between 139 ± 19 and 424 ± 32 mins/night.

CONCLUSION
Despite the high level of PA observed across the first 12 weeks of RMO training, participants experienced elevated β-CTx (bone resorption), with no concomitant rise in P1NP (bone formation), suggesting imbalanced bone turnover. Poor sleep habits quantified in this work may be contributing to this imbalance, impairing recovery and blunting the osteogenic response. An absence of raised IL-6 suggests these effects are likely driven by mechanical loading and inadequate recovery, rather than systemic inflammation. Whilst this response may have been transient, monitoring over a longer duration would be beneficial.

MILITARY IMPACT
These findings highlight factors that could be contributing to bone vulnerabilities in early phases of military training. Strategies to better mitigate injury risk by monitoring bone health, and ensuring adequate nutrition and improved PA periodisation, to support trainees' recovery are warranted. Such measures may enhance operational readiness and safeguard long-term health and performance.

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Thematic 5 : Prevention of musculoskeletal injuries

#46795355
Poster Presentation

Prospective Risk Factors for Low Back Pain in Military Personnel: A Systematic Review and Meta-Analysis

BACKGROUND
Low back pain (LBP) is one of the most common causes of medical presentation, training restriction, and reduced operational readiness in military populations. Although numerous prospective cohort studies have investigated predictors of LBP in service members, findings remain fragmented and difficult to interpret collectively. This study aimed to identify prospective risk factors for LBP in military personnel and quantify their associations through systematic review and meta-analysis.

METHODS
Literature screening, study selection, and data extraction were conducted using Covidence in accordance with PRISMA guidelines. Risk of bias was assessed using the Prediction model Risk Of Bias ASsessment Tool (PROBAST). Prospective cohort studies investigating predictors of incident LBP in military populations were included. Extracted ratio effect estimates (odds ratios, hazard ratios, incidence rate ratios, and risk ratios) were analysed on the log ratio scale using random-effects meta-analysis with restricted maximum likelihood estimation. Where multiple contrasts were reported within a study, a single estimate per risk factor was retained to avoid double counting, and comparator directions were harmonised where required. Heterogeneity was quantified using I^2 and τ^2.

RESULTS
Seventeen prospective studies involving more than 13 million service members were included. PROBAST assessment indicated that 16 of the 17 studies were judged to have high overall risk of bias, with the most common concerns arising in the predictors and analysis domains, reflecting inconsistent predictor definitions and limitations in analytical methods. Female sex was associated with increased risk of LBP (pooled ratio 1.45, 95% CI 1.10–1.90; k=8). Military rank was also associated with LBP incidence (1.67, 95% CI 1.46–1.89; k=6), suggesting differential exposure or reporting across rank groups. Race/ethnicity demonstrated a modest association (1.26, 95% CI 1.10–1.44; k=5), while service branch differences were also observed (1.75, 95% CI 1.22–2.50; k=5). Age showed the largest pooled association (4.63, 95% CI 2.11–10.19; k=10), although age contrasts varied considerably across studies. Substantial heterogeneity was observed across analyses (I^2 >98%). Limitations Age and service branch contrasts varied across studies, and pooled analyses included multiple ratio effect measures (OR, HR, IRR, RR). Residual confounding within primary studies and variation in outcome definitions may also contribute to the observed heterogeneity.

CONCLUSION
Demographic and occupational characteristics—including sex, age, rank, and service branch—are associated with prospective risk of LBP in military populations. However, the predominance of high risk-of-bias studies and substantial heterogeneity highlight important limitations in the current evidence base. These findings emphasise the need for improved design and harmonisation of prospective military injury risk factor studies, including more consistent definitions of predictors, outcomes, and comparator groups to enable reliable risk estimation and inform prevention strategies

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Thematic 5 : Prevention of musculoskeletal injuries

#46796235
Poster Presentation

Association Between Side Hop Limb Symmetry and Self-Reported Lower Quadrant Musculoskeletal Pain During Military Airborne Training.

BACKGROUND
Musculoskeletal (MSK) problems are common during military airborne training due to high-impact landings and repeated lateral loading. Identifying soldiers at higher risk is crucial for safety and operational readiness. Limb symmetry, measured via the side hop test, may influence susceptibility to MSK pain, particularly in those with or without pre-existing injuries. Objective: To examine the association between side hop limb symmetry and lower quadrant MSK pain following military airborne training, and how pre-existing injuries influence this relationship.

METHODS
One hundred fifty-six soldiers completed a 40 cm side hop test two weeks before military airborne training. Limb symmetry index (LSI) was calculated and categorized (<90% vs ≥90%). Pre-existing lower quadrant injuries were recorded. Post-airborne course self-reported pain ≥3/10 was collected for the lower quadrant. Logistic regression assessed the independent and interaction effects of LSI and pre-existing injury on post-airborne course pain. Results: LSI alone and pre-existing injury alone were not significant predictors. The interaction between low LSI (<90%) and pre-existing injury was significant (β = -1.656, p = 0.028), indicating that low LSI increased pain risk primarily in soldiers without pre-existing injury. In soldiers with pre-existing injury, the association between low LSI and post-airborne course pain was weaker, possibly reflecting compensatory movement strategies.

CONCLUSION
Low limb symmetry in soldiers without prior injuries is associated with higher risk of post-airborne course lower quadrant MSK pain. Pre-existing injuries appear to influence this risk. These findings support screening for limb asymmetry in apparently healthy soldiers to guide targeted prehabilitation for military airborne training.

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Thematic 5 : Prevention of musculoskeletal injuries

#46804327
Poster Presentation

Effects of Nicotine Use on Tibial Bone Adaptions in Men During 12 Weeks of Arduous Military Training

BACKGROUND
Musculoskeletal injuries (MSKI) and disorders are the principal cause of medical discharge from the British Army. Previous research has established associations between tobacco cigarette smoking and increased MSKI risk. More recently, nicotine use behaviours have migrated from tobacco cigarette smoking to increasing prevalence of e-cigarette use, the effect of which remains unknown in arduous military training. This study assessed nicotine use on measures of tibial macrostructure and microarchitecture during arduous military training in men.

METHODS
83 male British Army trainees participated in a longitudinal repeated measures observational study. Participant characteristics were: age, 21(3) years; height, 177(7) cm; body mass, 76.7(12.0) kg; and; waist circumference, 81.1(7.5) cm. Trainees in week 1 of initial infantry training completed a validated nicotine use questionnaire to assess e-cigarette, tobacco cigarette and other nicotine product use. Participants were divided into nicotine users (NIC, n 48) and non-user controls (CON, n 35). A high-resolution peripheral quantitative computed tomography scan was performed on the trainee's non-dominant lower leg (4% site) in weeks 1 (T1) and 12 (T2) of training. Differences in tibial macrostructure and microarchitecture between groups (NIC and CON) and over time (T1 and T2) were analysed using a two-way mixed model ANOVA.

RESULTS
Nicotine use status did not influence overall bone density or cortical bone adaptions. However, significant group x time interactions were observed in trabecular microarchitecture remodelling ($P<0.05$). Post-hoc analyses revealed a significant increase in trabecular number for CON (Δ 0.09 1/mm) and a non-significant decrease for NIC (Δ -0.06 1/mm) across training. Trabecular thickness did not change over time in CON but increased significantly in the NIC group (Δ 0.004 mm). Trabecular separation decreased in CON (Δ 0.02 mm) but did not change in the NIC group.

Regardless of nicotine status, there was a significant effect of training time ($P<0.05$) on bone density (Δ -15.6mg HA/cm3), trabecular bone density (Δ -9.44mg HA/cm3), trabecular bone to tissue volume ratio (Δ -0.008), trabecular thickness (Δ -0.002mm), trabecular separation (Δ +0.009mm), cortical thickness (Δ -0.039mm) and cortical area (Δ -1.48mm2).

CONCLUSION
While no between-group differences were observed in bone density or cortical thickness, changes in trabecular microarchitecture suggest adaptations to improve bone strength in the CON group, whereas nicotine use negated these effects. Additionally, increases in trabecular thickness in the NIC group suggest adaptions through compensatory remodelling by thickening existing trabeculae rather than creating new trabecular bone following high-impact loading. Further research should explore the independent impacts of different nicotine use behaviours (e.g. cigarettes, e-cigarettes, pouches) and incorporate biomarkers of bone turnover alongside MSKI outcomes to better understand the relationship between nicotine use and skeletal health.

MILITARY IMPACT
While current UK military guidelines advocate that e-cigarette use is preferable to tobacco smoking, empirical evidence into the effects of e-cigarette use on MSKI risk is minimal. This research provides understanding of e-cigarette use to inform future policy and minimise MSKI risk.

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Thematic 5 : Prevention of musculoskeletal injuries

#46813167
Poster Presentation

Hip Pinning Procedures and Musculoskeletal Injuries During U.S. Army Initial Entry Training and the Future Soldier Preparatory Course

BACKGROUND

Musculoskeletal (MSK) injuries represent the most significant health challenge facing the United States military, accounting for approximately 39% of all medical encounters. These injuries result in higher attrition and increased medical costs. Hip pinning surgeries have been a critical intervention during Initial Entry Training (IET) for recruits experiencing severe MSK injuries, particularly stress fractures and other hip-related injuries.

METHODS

This study leveraged data from electronic medical records; hip pinning procedure codes were analyzed to identify hip pinning cases across multiple fiscal years. Data collection focused on U.S. Army IET and the two tracks of the Future Soldiers Preparatory Course (FSPC). We used medical records to identify MSK injuries, and trainees with hip pinning procedures during training were identified in collaboration with training location leadership. Hip pinning procedure and MSK injuries were stratified by fiscal year (FY), sex and training location. Rate ratios were calculated, comparing men and women in the FSPC tracks (Academic Skills Development Program, Assessment of Recruit Motivation and Strength) with those who did not participate in FSPC. Hip pinning and MSK injury rates were assessed using chi-square analysis. Statistical significance was set at the 0.05 level.

RESULTS

From FY 2017 to FY 2025, 626 hip pinning cases were identified across four IET installations. While hip pinning rates increased for men from FY 2023 to FY 2024, IET injury rates decreased for both men and women during the same period. Women experienced statistically significant higher rates of MSK injuries compared to men in each FY and each training type ranging from 1.83 (CI: 1.77–1.89; p-value > 0.01) to 2.24 (CI: 2.14–2.34; p-value > 0.01). MSK injury rates during IET declined for men over time but remained elevated for women.

Injury rates in the Assessment of Recruit Motivation and Strength track were substantially higher than FSPC non-participants, particularly among men: Injury risk ratios, Assessment of Recruit Motivation and Strength vs FSPC non-participants: men: 2.41 [95% CI: (2.26–2.56); p>0.01] women: 1.68 [95% CI: (1.53–1.84); p>0.01] Trainees in the Assessment of Recruit Motivation and Strength track experienced higher injury rates than Academic Skills Development Program track trainees in most years. For women during the entire time period, the injury rates were 28.6 injuries per 100 person-months and 22.5 injuries per 100 person-months, respectively. For men overall, the injury rates were 19.3 and 14.6 injuries per person-months, respectively.

CONCLUSION

Fort Jackson, which trains almost half the new IET population each year, consistently reported the highest number of hip pinning cases across fiscal years, although rates varied. The higher injury rates among FSPC trainees, particularly those in the Assessment of Recruit Motivation and Strength track, suggest that these recruits may require additional surveillance and tailored injury prevention measures to mitigate risks associated with the sharp increase in physical demands during training.

MILITARY IMPACT

The findings highlight the need for data-driven injury prevention strategies, particularly for women and high-risk populations such as FSPC participants. By addressing injuries and hip pinning cases, the U.S. Army can better meet IET recruitment goals, improve training outcomes, reduce medical costs, and ensure a more resilient force.

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Thematic 5 : Prevention of musculoskeletal injuries

#47174470
Poster Presentation

Multidisciplinary Approaches are Needed for Prevention of Musculoskeletal Injuries: Importance of Multidirectional Loading for Skeletal Health

BACKGROUND

Musculoskeletal injuries (MSKI), such as bone stress injuries (BSIs), are overuse injuries common to initial military training scenarios such as U.S. Army Basic Combat Training (BCT). The multifactorial nature of these injuries highlights that prevention strategies for MSKI and BSI should be multifaceted. One such strategy is the use of multidirectional loading for promotion of bone health. History of multidirectional sports (MDS) participation in youth is associated with greater bone size, strength, and microarchitecture compared to those who did not participate in MDS. We hypothesized that MDS participation would result in more favorable bone properties and reduce BSI risk during training compared to never having played a sport.

METHODS

As part of a prospective observational study, participants (men=1931; women=1153) completed surveys at the beginning of BCT to describe sport participation from ~ age 5 until military entry. Participants were categorized for analyses based on sports reported with the highest level of osteogenic potential [MDS, non-multidirectional sports (non-MDS; running) or as having no sports participation (NS)]. Bone mineral density (BMD), area, microarchitecture, and strength were assessed at the distal tibia at the beginning of BCT using high-resolution peripheral quantitative computed tomography and finite element analysis. BSIs were radiographically confirmed in the first 16 weeks of military training (BCT + 6 weeks). Sex stratified multivariable generalized linear models, adjusted for age, race/ethnicity, height, weight, prior tobacco use, and contraceptive use (females only) were used to determine the relationship between sport loading category and baseline bone parameters. Multivariable logistic regressions, additionally adjusted for history of stress fracture, were used to assess the relationship between sport loading category and BSI.

RESULTS

Distribution of BSIs by group were different in men [MDS=77(5.1%), non-MDS=11(8.5%), NS=28(9.9%), p<0.01] but not women [MDS=141(16.2%), non-MDS=25(23.8%), NS=36(20.0%)]. In men, MDS had 50% reduced odds of BSI compared to NS [odds ratios (95%CI), 0.50 (0.31, 0.78), p<0.01], but this relationship did not reach significance in women [0.72 (0.49, 1.05), p=0.09). In men, MDS had 4.5% greater total BMD, 5.6% greater trabecular BMD and 2.0% thicker trabeculae compared to NS (p<0.01 for all). Only trabecular thickness was different in non-MDS men compared to NS (p<0.01). In women, MDS had 3.4-4.1% greater total BMD, 3.6-5.5% greater trabecular BMD, 8.3-12.7% stronger bones, and 1.3-2.2% thicker trabeculae compared to non-MDS and NS (p<0.01 for all).

CONCLUSION

These data demonstrate that MDS participation prior to military entry reduces risk of BSI during training. This relationship was not statistically significant in women which may be related to differences in sports played, duration of participation, or other lifestyle factors (e.g. sleep, diet). In both sexes, MDS is associated with more favorable bone properties at the beginning of military service. These data highlight the potential role of multidirectional loading for bone strength and injury reduction.

MILITARY IMPACT

Physical training programs often focus on stationary strength and conditioning and unidirectional (e.g. running) activities. Safely incorporating multidirectional loading into training programs may support a stronger, more injury resistant musculoskeletal system.

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Thematic 6 : Sleep in High Intensity context

Le Grand Salon - Mod: F. Sauvet + N. Pattyn + P. Helmhout

ORAL PRESENTATIONS

Sleep during a large scale military exercise: Effects on performance and readiness of Airforce personnel

Testing Alternative Shipboard Mattresses to Improve Sleep and Readiness in U.S. Navy Surface Sailors

Wearable-based Soldier Fatigue Monitoring in an Operational Environment – Practical Lessons and First Results of an Observational Study during Two International Military Exercises

Factors Impacting Sleep Across Deployment in United States Navy Aviation Personnel

From the Lab to the Field: Sensor-Based Military Fatigue Monitoring – Evidence, Challenges, and Pathways to Explore

Attentional recovery after a short sleep opportunity following total sleep deprivation: No association with acute sleep architecture but a key role of prior sleep regularity

Real-World Continuous Sleep Monitoring in Special Operations Forces: A 21,000-Night Longitudinal Investigation Using Wearable Heart-Rate-Variability and Digital Behavioral Intervention.

POSTER PRESENTATIONS

Human Peak Performance in Special Operations Forces: A Multimodal, Longitudinal Intervention Study on Stress, Recovery, and Health Optimization

Physical and Behavioral Characteristics Associated with Sleep Duration in United States Army Reserve Soldiers

Impact of acute sleep disruption on mitochondrial function and susceptibility to pathogens of human peripheral blood mononuclear cells, a study protocol

Effects of a total sleep deprivation on progressive complex shooting task during a military fatigue training course

Effects of a multi-model intervention for optimising sleep and internalising symptoms in British Army Infantry recruits - a pilot study

Comparison of sleep monitoring device Somfit versus polysomnography for long (8h) and short (3h) sleep opportunities.

A Novel Survey of U.S. Navy Sailors to Inform the Design of Next-Generation Shipboard Mattresses that Improve Sleep and Readiness

Effects of morning versus evening exercise on sleep - Does timing matter?

Thematic 6
Sleep in High Intensity Context

#46652762
Oral Presentation

Sleep during a large scale military exercise: Effects on performance and readiness of Airforce personnel

BACKGROUND
The military mantra "train as you fight" emphasizes realistic training, which means that training exercises (such as those for the Airforce) often take place in physically and mentally demanding 24-hour environments including suboptimal sleeping conditions. However, this approach does not take into account the crucial role sufficient sleep has for recovery and (cognitive) human performance, particularly in high-demanding environments. To reconcile this discrepancy, further research is necessary to strike a balance between realistic training and optimal performance in an Airforce setting.

METHODS
As a first step towards addressing this, it is essential to quantify the impact of sleep deprivation on military performance in a realistic training setting. The objective of this study is to examine the impact of different types of sleep facilities on sleep and military performance in a high-intensity exercise setting. To achieve this an observational study was performed among Airforce personnel during a 3-week exercise. 55 participants (mean age 31.5 years, SD 6.7 years) consisting of personnel from two military helicopter squadrons (pilots, technical service and staff) participated in this study throughout the military exercise. Participants were asked to fill in the demographical questionnaire, after signing the informed consent at the start of the exercise. Thereafter, they were instructed to fill in sleep, fatigue and performance related questionnaires prior and after each duty during each day of the exercise. The questionnaires consisted of the physical and mental readiness (Acute Readiness Monitoring Scale, ARMS), sleepiness (Karolinska Sleepiness Scale, KSS), workload, and subjective sleep duration and quality (PSQI). A subgroup of the participants (n = 40) was provided an actigraphy device (objective sleep monitoring), and instructed to wear this throughout the exercise.

Correlation and regression analyses will be conducted between measures of sleep (duration and quality), and performance indicators (ARMS, KSS and workload), with sleep environment as an effect modifier. Initial analysis of the data indicates that sleep, cumulative suboptimal sleep and sleep facilities have a negative effect on performance indicators. This shows that lower sleep (duration and quality) is associated with higher sleepiness, increased experience of workload, leading to lower acute readiness. Sophisticated statistical analyses needs to be performed in order to confirm this observation.

RESULTS
The final results of the data analyses will be shared during the ICPSS conference, together with our experiences on conducting a measurement campaign in a large scale Airforce exercise. The results of this observational study will provide insights into whether sleep conditions during an Airforce exercise will have an effect on indicators influencing performance measures such as acute readiness and sleepiness.

MILITARY IMPACT
Uncovering the impact of reduced sleep conditions on military personnel is mission-critical for enhancing their employability in high-stakes environments, such as large-scale operations, and for developing targeted strategies to boost resilience, optimise performance, and ensure operational readiness. The study will identify key sleep factors that influence specific performance measures, informing the development of targeted strategies to optimize military performance during high-intensity exercises and operations

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Thematic 6
Sleep in High Intensity Context

#46708549
Oral Presentation

Testing Alternative Shipboard Mattresses to Improve Sleep and Readiness in U.S. Navy Surface Sailors

BACKGROUND
Sleep is a critical factor for health, performance, and operational readiness. One of the most highly reported factors impairing sleep quality among Sailors is an uncomfortable shipboard mattress. Our previous in-laboratory pilot study found that a soft foam consumer mattress was superior to a standard Navy innerspring mattress for subjective comfort and sleep quality. This study extends the work using a larger sample while sleeping aboard an operational Navy ship across more nights using three mattress types.

METHODS
Active duty Sailors (N = 52; 41 males, 11 females) participated for nine nights on their assigned ship while in port; sleeping three nights each on: 1) a Navy standard innerspring mattress, 2) a consumer polyurethane soft foam mattress, and 3) a firmer consumer foam/coil hybrid mattress. Objective sleep was assessed with two devices: an electroencephalography forehead patch (Somfit; Compumedics Ltd.) and a smart ring (Oura, Gen. 4; Oura Health Oy). Each morning, Sailors rated their sleep and mattress comfort via questionnaire. Participants were blinded to the mattress conditions, and the order was randomized and counterbalanced.

RESULTS
Significant differences were observed for all subjective mattress ratings (comfort, support, firmness, temperature regulation, feeling discomfort/pain; all $p < .001$) and most subjective sleep outcomes (e.g., sleep quality, alertness upon waking, sleep efficiency, sleep onset latency; all $p < .05$), favoring the soft foam mattress over both the Navy standard innerspring and consumer hybrid mattresses, with medium to large effect sizes. These differences remained after controlling for potential confounding factors (e.g., sex, body mass index, age). In contrast, objective device-measured sleep outcomes did not differ between any mattresses (e.g., total sleep time, number of awakenings, sleep stages).

CONCLUSION
These results suggest that some mattresses constructed of different materials (but with similar dimensions) may offer improvements over current Navy shipboard mattresses in supporting Sailor sleep and readiness. This is consistent with previous survey and lab pilot study results that identified uncomfortable mattresses as a significant and modifiable factor influencing perceived sleep quality. Further work is needed to determine how mattresses can be designed to enhance comfort and sleep, while still meeting material, safety, and operational requirements for shipboard use.

MILITARY IMPACT
Improving sleep quality and quantity is critical for enhancing warfighter health and readiness. Developing and adopting new mattress designs for surface ships could address a modifiable barrier to optimizing operational sleep, while supporting command-level mission effectiveness and well-being for individual Sailors.

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Thematic 6
Sleep in High Intensity Context

#46709965
Oral Presentation

Wearable-based Soldier Fatigue Monitoring in an Operational Environment – Practical Lessons and First Results of an Observational Study during Two International Military Exercises

BACKGROUND
In operational environments, soldiers can face highly demanding circumstances that exhaust physical and mental resources, causing fatigue. When fatigued, soldier performance declines, lowering their effectiveness and increasing the risk of accidents that could cause harm to themselves or others. Continuous and automated fatigue monitoring via (wearable) sensors could help increase awareness and potentially provide feedback that may facilitate time-mitigating interventions. Studies in relatively controlled, fixed-workstation environments (e.g., pilots, drivers or control room operators) exist, as well as studies in Marines, but field studies in more ambulatory military personnel are scarce. To explore the potential of a currently available off-the-shelf military smartwatch for military fatigue monitoring, this study investigates to what extent wearable-based sleep, recovery, and prior-day load data can be used to predict morning subjective and objective fatigue.

METHODS
In this study, 12 air assault brigade soldiers and 33 infantry soldiers were monitored during two international large scale military exercises, both spanning approximately two weeks. In both groups, participants continuously wore a Garmin Tactix 8 smartwatch to collect data on total sleep time, sleep efficiency, nocturnal heart rate variability, resting heart rate and maximal body battery, as well as steps, active calories, maximum heart rate, average stress level and minimum body battery.Each morning, they also performed a 3-minute Psychomotor Vigilance Test (PVT) to assess their objective alertness and completed a brief morning questionnaire on their perceivedphysical and cognitive fatigue based on the Acute Readiness Monitoring Scale. Using a backwards modeling approach, Linear Mixed-effects Models were created to predict reciprocal mean reaction time and number of lapses on the PVT, whereas Cumulative Link Mixed-effects Models were created to predict subjective physical and cognitive fatigue.

RESULTS
Preliminary results indicate that there is predictive value in the collected wearable data when modelling both PVT performance metrics and subjective measures of physical and cognitive fatigue. Participant's questionnaire and PVT compliance was at least 69% between the two exercises. At the 7th ICSPP in Paris, more results and lessons learned on executing wearable-based studies in this type of setting are shared.

CONCLUSION
As expected, monitoring fatigue among infantry is very challenging, but not a mission impossible. Preliminary analyses suggest that wearable-derived indicators of sleep, recovery, and prior-day load may predict subjective and objective morning fatigue in operational settings. Further analyses will determine the robustness and practical value of these associations for improving military fatigue-monitoring strategies.

MILITARY IMPACT
By exploring the predictive value of a commercially available military smartwatch for fatigue monitoring in combination with practical lessons on its use in this type of operational setting, this study contributes potentially actionable insights for both military decisionmakers and researchers.

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Thematic 6
Sleep in High Intensity Context

#46739810
Oral Presentation

Factors Impacting Sleep Across Deployment in United States Navy Aviation Personnel

BACKGROUND
Insufficient sleep can compromise performance and readiness. Operational demands limit sleep opportunities and quality, so sleep monitoring may be viable in identifying risks from insufficient sleep impacting safety and mission effectiveness. Additionally, monitoring sleep can allow for the timely deployment of mitigation strategies to address insufficient sleep in military settings. Here, we characterized sleep in a sample of United States Navy (USN) aviation personnel across operational conditions and roles and characterized factors disrupting sleep.

METHODS
Personnel from three carrier deployments (404 carrier personnel, 147 aviation squadron personnel) wore a commercial wearable device (OuraTM Ring) continuously to assess total sleep time (TST) during the in-port work up and throughout deployment. A subset of personnel also completed mid-deployment surveys, which assessed factors that disrupted sleep on the ship (e.g., work demands, berthing temperature, flight noise). ANOVA was performed to examine the effects of operational conditions (in port vs. deployed) and rank (officer vs enlisted personnel) on sleep duration.

RESULTS
Sleep duration varied across operational condition ($F_{1,530.25} = 57.35$, $p < .001$) and rank ($F_{1,545.34} = 18.70$, $p < .001$). Sailors had shorter TST in-port prior to deployment (TST = 6.6 ± 0.7h; 26,618 person-nights) than during deployment (TST = 6.8 ± 0.9h; 48,590 person-nights). Further, enlisted personnel (n = 482, 6.6 ± 0.7h) had shorter TST than officers (n = 92, 7.0 ± 0.6h). No statistically significant interaction effect was found. The most common factor disturbing sleep was reported to be mattresses, with 33% reporting that mattresses affected their ability to sleep on board quite a bit/extremely. Other commonly reported factors included scheduled work (26%), unexpected work (25%), crewmate noise (25%), and stress (24%).

CONCLUSION
Sleep was shorter during the in-port work up to deployment, suggesting that Sailors may already be experiencing the effects of chronic sleep loss at the beginning of deployment. Further, while sleep duration was longer during deployment, many Sailors reported different factors disrupted their sleep when sleeping onboard the ship; this may have implications for sleep quality. Addressing sleep and fatigue factors among aviation personnel, both in port and during prolonged at-sea periods, is critical given the potential of sleep to serve as a combat-readiness enabler.

MILITARY IMPACT
Short sleep prior to deployment and sleep disturbances throughout deployment may have implications for Sailor performance and well-being across different operational phases. Identifying the factors that contribute to sleep disturbances during deployment is essential to inform mitigation strategies to support crew readiness. For example, modifying mattresses may reduce sleep disturbances in shipboard aviation personnel.

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Thematic 6
Sleep in High Intensity Context

#46772449
Oral Presentation

From the Lab to the Field: Sensor-Based Military Fatigue Monitoring – Evidence, Challenges, and Pathways to Explore

BACKGROUND
Military personnel often operate under demanding and unpredictable conditions that can lead to fatigue, affecting performance and safety. Continuous sensor-based monitoring of emerging or accumulated fatigue may improve awareness or support timely interventions. Although many studies address fatigue monitoring in civilian and military settings, the vast majority is focused on relatively controlled, fixed-workstation environments (e.g., pilots, drivers or control room operators), while few examine (military) field contexts. Existing reviews highlight the need for more deployed or ambulatory studies, where technological constraints and environmental variability challenge data reliability and interpretation. However, a synthesis of what sensor-based fatigue monitoring can already achieve in different military field settings – and where important gaps remain – is still lacking. This literature review aims to provide such an overview, as well as discuss potential pathways towards fatigue monitoring to gradually move from the lab to the field.

METHODS
This work draws on an ongoing exploration of the scientific literature on continuous and automatic sensor-based fatigue monitoring in military contexts. Relevant publications were identified through major databases (e.g., PubMed, Scopus) and reviewed to understand what has been demonstrated in different military field settings, which approaches still face technical or practical challenges, and which developments remain untested in operational environments. Attention was also given to the physiological, behavioral, and performance-related indicators most commonly examined, and to recurring methodological considerations shaping their applicability in real-world military conditions.

RESULTS
The review highlights themes regarding the feasibility, limitations, and unrealized potential of sensor-based fatigue monitoring in various military field settings. The emerging patterns and illustrative examples identified so far will be presented at the 7th ICSPP in Paris.

CONCLUSION
As this review progresses, it aims to synthesize the current state-of-the-art evidence on the feasibility of sensor-based fatigue monitoring in military field environments, highlighting demonstrated capabilities, persistent limitations, and emerging opportunities that may guide future work toward practical operational use.

MILITARY IMPACT
By outlining past work, knowledge gaps, and persistent challenges in sensor-based fatigue monitoring across military field settings, this review strengthens the knowledge base needed to guide future military research and development. In highlighting emerging directions that may support more informed design choices in future field studies. These insights may help defense organizations identify where additional evidence or innovation is required before operational use becomes feasible.

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Thematic 6
Sleep in High Intensity Context

#46787366
Oral Presentation

Attentional recovery after a short sleep opportunity following total sleep deprivation: No association with acute sleep architecture but a key role of prior sleep regularity

BACKGROUND
High-intensity operations involve maintaining a high level of cognitive performance despite rare and short sleep opportunities. Thus, managing recovery becomes essential. However, the recovery sleep features supporting cognitive restoration remain unclear. This study aimed to identify parameters of a short recovery sleep opportunity (3h time in bed, TIB) associated with attentional recovery after total sleep deprivation (TSD, 40h of continuous wakefulness).

METHODS
36 healthy subjects (17 women, 32.7±7.3 years) underwent a 4-day/4-night protocol: day 1 (D1) followed an 8-hour TIB baseline night (BS), D2 followed TSD, D3 followed a 3-hour TIB recovery sleep (R1), and D4 followed an 8-hour TIB recovery sleep (R2). Each day, Psychomotor vigilance task (PVT) performance (lapses/speed) was assessed every 3 hours and averaged. According to latent state-trait analysis, a recovery index adjusted for TSD vulnerability was derived from the residuals of a robust regression relating performance deterioration [lapses(D2)–lapses(D1)] to recovery gain [lapses(D2)–lapses(D3)]. Subjects were classified as efficient (ER) or inefficient (IR) recovery via median split (n=18 in each group). Actigraphy for 7 days prior to the study allowed calculation of habitual total sleep time and sleep regularity index. During the experimental sessions, sleep macrostructure parameters (total sleep time, sleep efficiency, sleep latency, wake after sleep onset, sleep stages duration and proportion), relative spectral power during non-rapid eye movement sleep (delta, theta, alpha, sigma and beta bands), as well as slow-oscillations characteristics (density, slope, duration and frequency) in the frontal derivations were acquired by polysomnography. PVT lapses and speed were analysed using repeated measures ANOVA (day and group factors), and sleep parameters via t-tests for independent groups.

RESULTS
PVT lapses and speed showed significant day ($p<0.01$, $\eta2p=0.53$; $p<0.01$, $\eta2p=0.66$ respectively), group ($p=0.03$, $\eta2p=0.13$; $p<0.01$, $\eta2p=0.19$) and interaction effects ($p<0.01$, $\eta2p=0.13$; $p<0.01$, $\eta2p=0.13$). Performance declined during D2, partially recovered during D3 and fully recovered during D4. ER and IR were comparable during D1/D2 but differed during D3 for lapses and speed ($p=0.02$ and $p=0.01$, post hoc-corrected), supporting recovery differences beyond trait-like TSD vulnerability. No univariate polysomnographic differences were observed during R1, but ER subjects exhibited higher pre-study sleep regularity ($p<0.01$, Cohen's $d=0.99$).

CONCLUSIONS
These findings suggest that pre-existing sleep regularity may contribute more strongly to short-term attentional recovery than conventional macro- and micro-architectural sleep metrics.

MILITARY IMPACT
In the absence of evidence for electrophysiological sleep monitoring on-duty, actigraphy-based monitoring may help identify individuals at risk of insufficient cognitive recovery prior to high-intensity operations.

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Thematic 6
Sleep in High Intensity Context

#46794160
Oral Presentation

Real-World Continuous Sleep Monitoring in Special Operations Forces: A 21,000-Night Longitudinal Investigation Using Wearable Heart-Rate-Variability and Digital Behavioral Intervention.

BACKGROUND
Elite military environments, including Special Operations Forces (SOF), frequently require personnel to sacrifice sleep in response to operational demands, despite the well-established role of sleep in physiological recovery, cognitive functioning, and performance regulation. Nevertheless, empirical evidence describing sleep patterns under ecologically valid field conditions remains limited, and little is known about how scalable, long-term sleep interventions can be implemented within such demanding operational contexts.

METHODS
Over a period of 15 months, the sleep macrostructure of 80 members of the Austrian Special Operations unit Jagdkommando was objectively monitored in a naturalistic setting. The study generated 21,512 nights of sleep data, reflecting high adherence to near-daily assessments. Sleep–wake classification was derived from heart rate variability (HRV) signals captured via the Polar Verity Sense and processed using the sleep² model with validated HRV-based staging algorithms. In addition to passive monitoring, the digital system delivered personalized feedback and evidence-based behavioral sleep guidance throughout the observation period.

RESULTS
Longitudinal analyses indicated gradual yet statistically reliable improvements in several sleep indices, even under sustained operational strain. Subjective sleep quality showed a small but consistent increase ($b = +0.01$, $p < .001$), accompanied by improvements in HRV-derived sleep scores ($b = +0.06$, $p = .007$). Intervention-specific effects further differentiated outcomes across groups. Sleep efficiency increased among participants receiving supplementation and those receiving the sleep² intervention, while no comparable change was observed in the control condition ($F = 3.49$, $p = .10$). Additionally, latency to consolidated sleep (defined as the time to 10 minutes of continuous sleep) was significantly reduced in both intervention groups but remained unchanged in the control group ($F = 2.77$, $p = .03$).

CONCLUSION
Together, these findings indicate that modest but measurable improvements in sleep can be achieved even in high-demand military environments. Continuous monitoring combined with structured behavioral support proved feasible over extended periods, with high adherence across participants.

MILITARY IMPACT
This integrated digital–physiological framework represents a scalable approach to promoting personalised recovery, resilience, and sustained operational performance.

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Thematic 6
Sleep in High Intensity Context

#46435331
Poster Presentation

Human Peak Performance in Special Operations Forces: A Multimodal, Longitudinal Intervention Study on Stress, Recovery, and Health Optimization

BACKGROUND

In elite military populations such as Special Operations Forces (SOF), long-term operational demands pose severe risks to physical and mental health. Despite extensive training and selection, SOF personnel face chronic stress, sleep disruption, nutritional deficits, and a lack of sustainable recovery strategies. Yet, few studies have systematically examined how stress, inflammation, sleep, gut health, and micronutrient status evolve over time in real-life military conditions – or how integrative interventions can enhance long-term resilience and performance. The goal of this project is to examine the cumulative physiological and psychological burden—conceptualized as allostatic load—in SOF personnel across multiple operational timepoints, to identify markers of vulnerability and resilience through dynamic assessments of biological, behavioral, and psychosocial parameters, and to inform tailored interdisciplinary interventions that reduce allostatic load, enhance recovery, and sustain operational readiness.

METHODS

This longitudinal, prospective research project follows 80 Austrian SOF soldiers over 15 months, including the full training and operational cycle. The study combines biomarker analysis (e.g. Serotonin, IL-6, Omega-3-FA, Vitamins, zonulin, calprotectin, kynurenine pathway), body composition monitoring (BIA), and continuous wearable tracking (Sleep² app, HRV, heart rate, sleep stages). Three intervention modules are implemented: 1. Heavy metal detoxification (Zeolite, DMSA, CaEDTA) 2. Micronutrient supplementation (Omega-3, Vitamin D3, K2, A, E, humic acids) 3. Individual Sleep equipment (pillows, mattrasses, blankets) Psychometric instruments (e.g., PSS-10, RS11, PSQI) are used to contextualize physiological changes. Sub-studies and follow-ups focus on training stress, gut barrier integrity, and nutritional availability (RED-S/RED-M).

EXPECTED RESULTS

It is hypothesized that early detection of allostatic load markers and personalized interventions will lead to improvements in stress resilience, sleep quality, gut health, and inflammatory status. A reduction in training-related dropouts and injuries is expected as an outcome of targeted performance and recovery optimization.

DISCUSSION

Human Peak Performance is the first comprehensive resilience and health monitoring study in European SOF. The integration of biometrics, psychometrics, and targeted biological interventions provides a scalable blueprint for performance medicine in elite military settings. Results may inform evidence-based guidelines for training management, recovery protocols, and health maintenance in high-performance populations.

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Thematic 6
Sleep in High Intensity Context

#46661491
Poster Presentation

Physical and Behavioral Characteristics Associated with Sleep Duration in United States Army Reserve Soldiers

BACKGROUND
Insufficient sleep has been associated with a range of negative health consequences such as obesity and higher daily stress. Insufficient sleep poses a significant public health concern and compromises medical readiness of U.S. Army Soldiers. The purpose of this analysis was to investigate the relationship between modifiable physical and behavioral characteristics and sleep duration among U.S. Army Reserve Soldiers. This unique military population typically has full-time civilian occupations, are geographically separated, and report for military duty one weekend a month and two weeks a year.

METHODS
Demographics, health behaviors, and health characteristics were obtained from U.S. Army Reserve Soldiers using an electronic survey that was completed as part of a program evaluation conducted in 21 Reserve units. Chi-square tests were used to evaluate differences in frequencies of categorical variables. Univariate and multivariable linear regression models were used to estimate the relationship between modifiable risk factors known to affect sleep duration and the overall number of hours slept per night.

RESULTS
Respondents consisted of 1,423 male and 514 female U.S. Army Reserve Soldiers. Approximately 45% reported not meeting the sleep recommendation guidelines of seven or more hours per night. Reported average sleep duration per night was 6.54±1.23 hours. Three modifiable risk factors were found to be associated with sleep duration; body mass index, reported stress, and caffeine consumption. Sleep duration decreased by 1.7 minutes per night for every one unit increase in body mass index ($p<0.001$), 19.1 minutes per night for those reporting moderate to high stress compared to low stress ($p<0.001$), and sleep duration decreased by 11.6 minutes per night, per increase in the frequency of caffeine consumption 6 hours before bed (rarely or never vs. sometimes ingesting caffeine 6 hours before bed (11.6 minutes per night); sometimes vs. most of the time and always ingesting caffeine 6 hours before bed (23.2 minutes per night), $p<0.001$).
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CONCLUSION
Sleep duration among U.S. Army Reserve Soldiers is associated with several modifiable risk factors. Command strategy, education and health interventions targeting U.S. Army Reserve Soldiers or those like them, should consider body mass, influences of stress and caffeine intake and caffeine intake timing.

MILITARY IMPACT
Army Reserve Soldiers provide critical support during deployments and emergencies requiring a rapid response. With approximately 45% of Soldiers not meeting recommended sleep duration guidelines, improving Army Reserve Soldiers sleep through changes of modifiable risk factors (e.g., BMI, stress, timing of caffeine intake) could improve overall military readiness and inform strategies for similar populations

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Thematic 6
Sleep in High Intensity Context

#46664414
Poster Presentation

Impact of acute sleep disruption on mitochondrial function and susceptibility to pathogens of human peripheral blood mononuclear cells, a study protocol

BACKGROUND
Military personnel engaged in large scale operations or intensive training undergo periods of sustained physical and mental exertion, often combined with fragmented or restricted sleep. Such conditions not only reduce cognitive and physical performance, but also leads to metabolic and immuno-inflammatory alterations, increasing susceptibility to infectious diseases. However, maintaining optimal immune health during deployment is a major operational concern. On the other hand, individual responses appear highly variable, making the early identification of those at-risk particularly challenging. Currently, there is no reliable tool that can accurately predict and prevent the deterioration of soldiers' immune function. Therefore, identifying biomarkers sensitive to environmental constraints, such as sleep debt, is crucial in order to anticipate health risks and guide recovery strategies. Given their central role in energy production and cellular metabolism, mitochondria may be a key target of sleep-related stress. While sleep deprivation has been associated with immune dysfunction, its effects on mitochondrial function remain poorly characterized. The primary objective of this study is thus to assess the impact of acute sleep debt, and two subsequent nights of recovery, on mitochondrial function in peripheral blood mononuclear cells (PBMCs). The study will also evaluate the sensitivity of these immune cells to different pathogens in vitro.

METHODS
This study will include 65 healthy volunteers. Ten days prior to admission to the sleep lab, they will wear an actimeter and will be instructed to maintain a sleep-wake cycle in line with their usual habits. During their time in the lab, they will participate in a 5-night experimental sequence under controlled conditions, according to the following schedule: (N1) a reference night (between 11:00 p.m. and 7:00 a.m.), (N2) a night of total sleep deprivation, (N3) a night of sleep restriction (between 4:00 a.m. and 7:00 a.m.), (N4/N5) two nights of recovery (between 11:00 p.m. and 7:00 a.m.).

Throughout the days, and during N2 and N3, participants will be kept awake through various activities, including cognitive tests and questionnaires. They will be prohibited from consuming coffee or any other stimulant. A fasting blood sample will be collected at 7:30 a.m. following N1 through N5. A complete blood count and PBMC isolation will be systematically performed. Plasma levels of stress and inflammatory markers will be measured. Mitochondrial function in PBMCs will be evaluated using high-resolution respirometry. In parallel, the immune cells will undergo various bacterial or viral stresses in vitro in order to study cytokine responses. This research protocol and project address a critical operational need: understanding the impact of sleep debt on soldiers to reduce absences related to non-battle diseases and injuries that could be linked to it.

RESULTS
The study aims to characterize the kinetics of metabolic and immune function impairment and to determine whether two nights of recovery are sufficient to fully restore these functions. Ultimately, the project seeks to develop a recovery index integrating clinical, physiological and biological parameters to objectively assess individual readiness.

MILITARY IMPACT
The expected outcome is the formulation of evidence-based recommendations regarding the minimum rest time required between engagement phases, with the goal of optimizing personnel rotation and maintaining operational performance.

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Thematic 6
Sleep in High Intensity Context

#46682547
Poster Presentation

Effects of a total sleep deprivation on progressive complex shooting task during a military fatigue training course

BACKGROUND
Military performance is impacted by many factors. One of the most important factors is sleep disorders. Because of high intensity conflict, the time allowed to recovery was uncertain because this was could be suppressed or shifted. Moreover, the military was authorised to wore a weapon and can use them within a specific legal framework and the lack of sleep during operational activities could lead critical situation involving decision making. Therefore, the aim of our study was to highlight the link between sleep restriction and a progressive complex shooting task in ecological situation.

METHODS
During a military training, fourteen members of French army was exposed to a total sleep restriction (39h) during one night. Participants were involved in a ecological shooting task with gradual decision making load. Pictures of people, generated by an AI, was projected on a screen. People could wore a weapon or not and a police armband or not. Participant had to make a choice (shoot or not) based on the analysis of the context. We separated the task in three level of difficulty. The first required a shoot for each situation. The second level required an analysis of the presence or absence of a firearm. In the third level of difficulty, we added a second kind of stimuli, bringing uncertainty in the decision with a police armband. This task was performed and recorded three times : baseline day, after a total sleep restriction and after a complete night.

RESULTS
From a frame-by-frame analysis, we were able to determine: reaction time, the decision to fire or not, and the accuracy of the shoot. we had lead a 2 factors linear mixed model with the day (ordinal 3 levels factor) and difficulty (ordinal 3 levels factor). Correlations were made using Pearson r coefficient. We showed a diminution of time reaction after a total sleep deprivation and increased of the number of shooting outside (+7.2 ± 4.3 %, p=0.02), also after a total sleep deprivation notably for a complex shooting task. This highlights the increased of impulsivity of people after a total sleep deprivation. We also showed that a total night was sufficient for restoring cognitive performance, notably attention in a complex task. We didn't observed omission or commission errors. We confirmed that total sleep restriction had a impact on a progressive complex shooting task. The absence of errors of omission and commission demonstrated that the simple situation analysis was not impacted by lack of sleep.

CONCLUSION
We demonstrated that a full night's sleep could erase the effect of a total sleep restriction on the number of shots out, and in the ability to analyse a situation, with fewer shots taken in situations where it was not necessary. A lot unit had laser gun in order to improved their training. This task was characterized by strong ecological validity, as it reproduced realistic situations closely reflecting operational constraints.

MILITARY IMPACT
It enabled the assessment and training of decision making processes in contexts faithful to real-world conditions. Its implementation aimed to enhance operational readiness directly within military units.

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Thematic 6
Sleep in High Intensity Context

#46716329
Poster Presentation

Effects of a multi-model intervention for optimising sleep and internalising symptoms in British Army Infantry recruits - a pilot study

BACKGROUND
Sleep disturbance and internalising symptoms are pervasive during military training. Unimodal sleep interventions show limited effectiveness in combat training environments, warranting scalable, evidence-based multi-component interventions. We assessed the effectiveness of a multimodal sleep intervention on subjective sleep outcomes, including insomnia, with secondary analysis of internalising symptoms (depression, stress) in Parachute Infantry recruits.

METHODS
Two-arm parallel design was employed (baseline: weeks 1-3; intervention: weeks 4-12). The multimodal intervention aligned with CBT-I components (psychoeducation, sleep hygiene, pre-bedtime "wind-down" routines, extended sleep). Surveys were completed at training start (pre-training status), end of week-3 (baseline), and week-12 (intervention end). Linear mixed models assessed group (n=40 control; n=43 experimental) and time effects (pre-training, baseline, intervention). Ordinal logistic GEE analysed categorical sleep quality (PSQI item-6).

RESULTS
Both groups experienced chronic sleep restriction. Driven by earlier waketimes, sleep duration significantly reduced from ~7-hours pre-training (95%CI: 06:39, 07:14hm) to ~5.5-hours during training (95%CI: 05:27, 05:47hm, p<0.001). During the intervention, the experimental group shifted daily bedtimes ~40-minutes earlier, achieving ~30-minutes more sleep than controls, reporting significantly better sleep quality (Exp(b)=0.11, p<0.001). Both groups reported increased daytime sleepiness during baseline relative to pre-training levels (p<0.001, 95%CI: 2.75, 7.54), but was significantly lower in the experimental group during the intervention compared to controls (p<0.001, 95%CI: 3.88, 7.69). While controls reported significantly worse insomnia than the experiment group at pre-training (8.3 ± 3.7 vs 5.4 ± 3.1, p=0.018, 95%CI: -5.1, -0.5), scores converged during baseline, with both exceeding clinically relevant levels (ISI >10).

The experiment group reported significantly reduced insomnia during the intervention compared to controls (4.7 ± 2.7 vs 9.1 ± 3.7, p <0.001, 95%CI: -6.5, -2.1). The experimental group reported significantly reduced stress (p=0.006, 95%CI: -8.5, -1.5) and clinically meaningful reductions in depressive symptoms (p<0.001, 95%CI: -7.7, -2.4) compared to controls during the intervention.

CONCLUSION
This multimodal intervention produced meaningful improvements in insomnia and internalising symptoms during combat training. No specific mental health interventions were delivered; thus, symptom improvements likely reflect sleep-driven effects, consistent with bidirectional models of sleep disturbance.

MILITARY IMPACT
Practical translation of sleep-related policies into training remains challenging in military organisations. Our findings demonstrate a scalable, evidence-based and behaviourally grounded sleep optimisation intervention, serving as a practical model for implementation into combat training environments.

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Thematic 6
Sleep in High Intensity Context

#46739628
Poster Presentation

Comparison of sleep monitoring device Somfit versus polysomnography for long (8h) and short (3h) sleep opportunities.

BACKGROUND
Sleep is a key determinant of operational performance among military. In the context of high intensity conflicts, operational constraints such as sustained operations, hostile environment and irregular schedules expose military to a significant sleep deprivation and reduction of his quality. This alteration led to an impairment in cognitive performance and compromise operational safety. Objective sleep monitoring in operational environments remains challenging, as gold-standard methods such as polysomnography are not feasible in field conditions. Based on this observation, many devices are developed to monitor sleep using actimetry, but these tools do not allow an in-depth study of sleep. Thus, electroencephalography devices are of great importance and have shown some promising results. In this context we seek to evaluate the performance of Somfit sleep monitoring devices based on electroencephalography chain for different time in bed conditions.

METHODS
In the present study we compared Somfit and polysomnography night recording obtained in laboratory (n=31). Based on standardized methods for assessing sleep monitoring devices we conducted an epoch-by-epoch comparison, discrepancy analysis for sleep parameters of interest (Sleep latency, Total Sleep time, Waking state after sleep onset) in two sleep conditions (8 hours and 3 hours of time in bed). We computed Cohen's Kappa, Agreement percentage and ANOVA for repeated measures for the epoch-by-epoch analysis. Bland Altman analysis has been conducted for sleep parameters discrepancy.

RESULTS
Our results show a kappa score of 0.58 [0.55; 0.61] and 0.53 [0.49; 0.57] with an agreement percentage of 69.90% [66.60; 72.40] and 73,01% [68.9; 77.1] for the 8- and 3-hour conditions respectively. There is no significant difference of kappa score ($F(2,58) = 2.14$, $p=0.126$) and Agreement ($F(2,58) = 0.428$, $p= 0,654$) between sleep conditions.

The sleep stages concordance analysis shows a good ability of the Somfit to detect N2, N3 and REM with significant confusion between N2 and N3 and a moderate discrepancy of sleep parameters.

CONCLUSION
Our results indicate moderate agreement with polysomnography-based scoring in lines with previous study and exceeding reliability threshold for interscorer variability (k =0.50). This level of agreement falls within the lower range of reported performance of electroencephalography sleep monitoring devices (typically k= 0.60-0.70) but substantially exceed non-electroencephalography wearable technology performance such as actigraphy.

MILITARY IMPACT
Our results open the way for possible applications of Somfit in military and high intensity conflicts context. His use can serve as behavioral prompts to optimize individual health, recovery and sleep management. However, more studies are needed on the translation between measures often assessed in sleep laboratories and military relevant performances outcomes.

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Thematic 6
Sleep in High Intensity Context

#46748090
Poster Presentation

A Novel Survey of U.S. Navy Sailors to Inform the Design of Next-Generation Shipboard Mattresses that Improve Sleep and Readiness

BACKGROUND
Navy shipboard mattresses are frequently reported as being uncomfortable and interfere with the ability to obtain high-quality sleep, with implications for Sailor readiness. Previous Navy surveys asked only general mattress-related questions and did not examine specific factors or preferences that could improve mattress designs. To address these limitations, we designed a new survey to capture more information on perceptions of sleep and mattress comfort, with the goal of informing ongoing efforts to develop next-generation shipboard mattresses.

METHODS
The survey is open to active duty U.S. Naval Surface Forces Sailors and includes multiple items assessing experiences with standard shipboard mattresses as well as preferences relevant to comfort, sleep quality, and future mattress design. Data collection began in July 2025 and is ongoing. Results reflect all responses received through 05 January 2026 (n = 326).

RESULTS
Responses range from a wide cross-section of Sailors from multiple ship classes, pay grades, and departments. Sailors rated shipboard mattresses as uncomfortable (77%), too firm (77%), and unsupportive (76%). Sailors also rated their shipboard sleep quality as poor (70%) and reported that mattresses contribute substantially to their perceived sleep quality (60%) and physical discomfort while sleeping (59%). Sailors indicated that mattresses feel too hot or too cold (70%) and increase fatigue levels (79%). Sailors further reported that limited overhead rack space restricts the ability to comfortably adjust their body position (71%), negatively affecting sleep (48%); however, a majority would still be willing to sacrifice some rack space for a taller, more comfortable mattress (64%). To improve comfort and sleep, Sailors expressed preferences for new mattresses that are softer (74%), taller (48%), more supportive in distributing body weight (69%), and better at regulating body temperature (58%).

CONCLUSION
Results from this novel survey corroborate previously reported poor experiences with shipboard mattresses among Sailors and provide new actionable insights into which specific factors could be addressed and prioritized to improve mattress comfort, sleep, and readiness. These Sailor-informed ratings and design preferences are intended to guide ongoing efforts to develop and test next-generation shipboard mattresses.

MILITARY IMPACT
Shipboard mattresses are widely considered by U.S. Navy Sailors to be uncomfortable and are one of the top factors interfering with their ability to obtain high quality sleep. However, mattresses are potentially modifiable and there is a current effort to design next-generation mattresses for Navy surface ships. Results from this novel survey identify specific areas for mattress improvement and other design recommendations that can help inform the effort to develop more comfortable shipboard mattresses with the aim of improving Sailor sleep and readiness.

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Thematic 6
Sleep in High Intensity Context

#46811629
Poster Presentation

Effects of morning versus evening exercise on sleep - Does timing matter?

BACKGROUND
Research on exercise and health has traditionally focused on parameters such as intensity, volume, and exercise modality, which shape physiological adaptations and influence cardiovascular, metabolic, and psychological outcomes (Galan-Lopez and Casuso, 2023). Recently, attention has shifted toward the temporal dimension of exercise, with evidence suggesting that the time of day at which exercise is performed may modulate physiological responses, including subsequent sleep patterns and sleep quality (Bennett and Sato, 2023). In military populations, sleep has also been identified as a key factor associated with musculoskeletal injury risk, highlighting the need to integrate sleep considerations into preventive strategies (Lisman et al., 2022). Moreover, improving sleep hygiene may contribute to enhancing soldiers' life satisfaction (Nema et al., 2024). This systematic review and meta-analysis therefore aimed to: (i) synthesize current evidence on the effects of morning versus evening exercise on sleep parameters, and (ii) identify factors that may explain differential effects between morning and evening exercise on sleep.

METHODS
This systematic review was conducted and reported in accordance with the updated guidelines of the PRISMA 2020 statement and was prospectively registered (PROSPERO ID: CRD42021277708). The academic databases SPORTDiscus, Scopus, Embase, PubMed, and PsycInfo were searched from 2000 to April 2024 to find peer-reviewed English-language primary research on the impact of exercise timing on sleep. Studies were identified by combining 3 sets of keywords linked to: (1) exercise, (2) timing, and (3) sleep.

RESULTS
Of 1,108 records identified, 19 studies met the inclusion criteria, including 12 randomized controlled trials (up to 493 participants) in the meta-analysis. Overall, the effects of exercise timing on sleep were small, with most sleep outcomes showing no significant differences between morning and evening exercise. These findings do not indicate that exercise timing is irrelevant for sleep; rather, timing effects appear diluted when averaged across heterogeneous populations and exercise protocols. Subgroup analyses suggest that timing effects may become more or less apparent depending on exercise characteristics and exposure pattern (acute versus chronic). Higher exercise intensity was associated with less favourable sleep continuity following evening exercise, whereas chronic compared with acute exercise tended to attenuate timing-related differences.

CONCLUSION
Collectively, these findings indicate that maintaining regular exercise is likely more important for sleep than the specific time of day at which it is performed especially when it comes to low to moderate intensity, supporting a re-evaluation of traditional exercise-timing recommendations.

MILITARY IMPACT
Insufficient sleep in the military is ubiquitous, with serious implications for the behavioral health and functioning of service members (Alger et al., 2024). Thus, leaders should attend to these risks and examine ways to promote healthy sleep in service members.

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Thematic 7 : Physical Performance tests and reasiness indicators Part II

Salle Moebius - Mod: T. O'leary

ORAL PRESENTATIONS

Development, Validation and Heat Strain Assessment of a Gender-Neutral, Role-Specific Physical Employment Standard for the Royal Netherlands Army (FIT-CLAS)

Physiological underpinnings of 2 km run time in British Army Infantry Soldiers: a cross-sectional observational study

From Cut-offs to Conditional Probabilities: Bayesian Multidomain Prediction of SOF Selection Success

When One Number Is Not Enough: From Cut-Score Uncertainty to Physical Readiness Zones in Tactical Applicant Testing

Limits of Physiological Screening in Special Forces Selection

Physical performance changes in a U.S. Army Reserve Command health and fitness pilot program

POSTER PRESENTATIONS

Velocity-Based Strength Training (VBT): A Key to Enhanced Warfighter Readiness?

The Rise of Pharmacotherapy for Obesity Among U.S. Armed Forces: Trends in Prescribing Prevalence and Implications for Physical Performance and Readiness

The Identification of Mobility Tests Sensitive to Differences Between Body-Borne Protective Systems

Physiological Profile of Danish Special Forces Operators: Implications for Human Performance Optimization

Perceived Service Member Fitness and Performance Gaps, and Military Task-related Physical Attributes Summary from NSCA's Third Blue Ribbon Panel on Military Physical Readiness

Physical Readiness in Candidates for the Danish Special Forces – A Preliminary Study

Insights into the new Norwegian short military marching capacity test

Epidemiology of Injury Incidence of Officer Cadets During Basic Military Training

Laser Biathlon Shooting Test to Objectify the Effects of Total Sleep Deprivation

Comparison of DEXA and Bioelectrical Impedance Analysis Whole-Body Composition Measures in CANSOFCOM Members

Effectiveness of a Pre-Basic Training Fitness Education Program on Physical Performance in Military Recruits

Association between pull-up test performance and body composition indicators in Brazilian Army military personnel

Thematic 7
Physical Performance tests and readiness indicators

#46496095
Oral Presentation

Development, Validation and Heat Strain Assessment of a Gender-Neutral, Role-Specific Physical Employment Standard for the Royal Netherlands Army (FIT-CLAS)

BACKGROUND
Modern armed forces require gender-neutral Physical Employment Standards (PES) that reflect operational demands while safeguarding health and performance. The Royal Netherlands Army developed FIT-CLAS, a role-specific, scenario-based PES aligned with international best practice. Because demanding tasks can impose substantial thermal stress, insight into heat load and strain during FIT-CLAS is essential for safe implementation, particularly in high-intensity contexts.

METHODS
FIT-CLAS was developed in four phases: job task analysis, physical demands analysis, scenario-based test design, and validation. Roles were clustered into six role groups (RGs) with comparable physical demands. The assessment comprises three consecutive subscenarios: 'Approach' (loaded march), 'Execute' (task simulations including repetitive lifting, obstacle run, casualty evacuation), and 'Depart' (rapid load-bearing movement). Duration ranges from one (RG1) to two hours (RG6). Heat strain was examined in a quantitative cross-sectional field study. Five RG1 and six RG4 soldiers completed FIT-CLAS in temperate conditions. Core temperature (Tcore) was continuously measured using ingestible telemetric capsules. Environmental heat load was monitored via Wet Bulb Globe Temperature (WBGT). Perceived heat strain was assessed after each phase using standardized thermal sensation and comfort scales. Group differences were analyzed with Welch's t-tests ($p<0.05$).

RESULTS
FIT-CLAS provides a gender-neutral, criterion-referenced assessment scaled to occupational demands. Physiological responses differed markedly between groups. RG1 showed a moderate total Tcore increase of 0.53 ± 0.42°C, with partial recovery during 'Execute'. RG4 demonstrated a continuous rise across phases, resulting in a significantly greater total increase of 1.08 ± 0.41°C. The 'Execute' phase drove this divergence (ΔTcore RG4: 0.32 ± 0.11°C vs RG1: -0.04 ± 0.17°C; $p=0.006$). Perceived heat strain increased progressively and was consistently higher in RG4, reaching 'hot' and 'uncomfortable' levels after 'Depart'. Average WBGT over two days was 10.31 ± 0.49°C and 12.49 ± 0.58°C.

CONCLUSION
FIT-CLAS is a valid and operationally relevant PES reflecting role-specific demands. However, higher-demand roles experience substantially greater physiological and perceived heat strain, particularly during task execution. Operational readiness depends not only on physical capacity but also on tolerance of acute thermal load during peak demands.

MILITARY IMPACT
By integrating task performance with physiological heat strain assessment, FIT-CLAS supports safe and defensible readiness evaluation. Findings underline the need for risk mitigation strategies such as targeted cooling, recovery planning, and physiological monitoring.

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Thematic 7
Physical Performance tests and readiness indicators

#46697153
Oral Presentation

Physiological underpinnings of 2 km run time in British Army Infantry Soldiers: a cross-sectional observational study

BACKGROUND
Role-based minimum 2 km run performance standards are required for entry into the British Army and are assessed annually throughout service to support training. Faster 2 km run time is associated with superior military task performance, including load carriage, and lower risk of musculoskeletal injury in military training. Few studies have explored the physiological underpinning of the 2 km run time using gold standard laboratory measures of aerobic capacity (oxygen uptake [VO2], maximal oxygen uptake [V̇O2max], ventilatory threshold [VT1], and respiratory compensation points [VT2]) and body composition. This study investigated associations between V̇O2max, VT1, VT2, and body composition with 2 km run time.

METHODS
One female and forty-six male infantry soldiers (mean ± SD, age 25.5 ± 5.7 years, height 1.78 ± 0.6 m, body mass 81 ± 11 kg, V̇O2max 48.8 ± 5.1 ml·kg-1·min, lean mass 60 ± 7 kg, body fat percentage 22 ± 5 %, VT1 57 ± 9 %V̇O2max, VT2 83 ± 6 %V̇O2max) volunteered to participate. Participants completed a best effort 2 km run time trial as part of routine military fitness testing and a separate laboratory visit where V̇O2max, VT1, and VT2 were measured from an incremental treadmill test; whole-body lean and fat mass were measured by dual-energy X-ray absorptiometry. Simple and multiple linear regression were used to determine associations between relative V̇O2max, treadmill speed at V̇O2max, treadmill speed at VT1 and VT2, VO2 at VT1 and VT2 (%V̇O2max), and body fat percentage with 2 km run time.

RESULTS
Simple linear regression revealed that faster 2 km run time was associated with higher V̇O2max ($R^2 = 0.42$, $p < 0.001$) and faster treadmill speed at V̇O2max ($R^2 = 0.45$, $p < 0.001$), VT1 ($R^2 = 0.15$, $p = 0.001$), and VT2 ($R^2 = 0.28$, $p < 0.001$). There were no associations between 2 km run time and V̇O2 at VT1 and VT2 ($R^2 \leq 0.01$, $p \geq 0.655$).

Multiple linear regression revealed that faster 2 km run time was associated with higher relative V̇O2max when controlling for VT1 (%V̇O2max), VT2 (%V̇O2max), and body fat percentage ($p < 0.001$, $R^2 = 0.429$), but VT1, VT2, and body fat percentage did not contribute significantly to the model.

CONCLUSION
Best effort 2 km run time is most strongly associated with maximal aerobic capacity and maximal aerobic speed , whereas submaximal parameters of aerobic capacity (VT1 and VT2) are relatively less important for performance.

MILITARY IMPACT
The 2 km run is a reasonable alternative to laboratory testing for aerobic capacity to suit large cohorts. Training strategies for 2 km run time should target maximal aerobic capacity and maximal aerobic speed.

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Thematic 7
Physical Performance tests and readiness indicators

#46731881
Oral Presentation

From Cut-offs to Conditional Probabilities: Bayesian Multidomain Prediction of SOF Selection Success

BACKGROUND
Fitness-related dropout substantially contributes to attrition during Special Operations Forces (SOF) selection. Screening procedures commonly rely on single performance thresholds (e.g., minimum VO_2max or strength standards), implicitly assuming readiness can be reduced to isolated cut-offs. Operational performance, however, likely depends on multidomain capability with compensatory strengths across aerobic fitness, strength, power, reaction speed, and executive control. This motivates a shift from threshold-based screening toward probabilistic multidomain profiling.

METHODS
We analyzed 137 Swiss Tier 1 and Tier 2 SOF candidates completing a standardized multidomain pre-selection battery reflecting operational task demands. Assessments included executive control (Stroop), visuomotor reaction speed using an FX handgun, striking power (PowerKube), isometric deadlift and pull-up one repetition maximum, loaded treadmill cardiopulmonary exercise testing assessing VO_2max and ventilatory efficiency, and dynamic balance. The binary outcome was selection success versus fitness-related dropout. Single-test discrimination was evaluated using receiver operating characteristics and illustrative Youden-derived cut-offs. To estimate individualized selection probability and model compensatory relationships between domains, Bayesian logistic regression models with pre-specified interaction terms were implemented. Out-of-sample predictive performance was evaluated using leave-one-out cross-validation and area under the curve (AUC).

RESULTS
Single-test cut-offs provided limited separation between candidates with selection success and those with fitness-related dropout. Executive control showed the strongest individual discrimination (AUC = 0.74; illustrative cut-off ≈ 58th percentile rank), whereas VO_2max, ventilatory efficiency, striking power, deadlift strength, reaction speed, and balance demonstrated only moderate discrimination (AUCs ≈ 0.61–0.65). No isolated marker reliably distinguished selection success from fitness-related dropout.

Multidomain Bayesian models improved predictive performance (AUC = 0.81). From a baseline 30% success probability, a 5 $ml \cdot kg^{-1} \cdot min^{-1}$ increase in VO_2max was associated with ~38% higher odds of selection success, +100 N isometric deadlift force with ~9% higher odds, and a 0.10 s faster reaction time with ~30% higher odds. Interaction effects indicated compensatory readiness patterns: higher aerobic capacity was particularly beneficial among weaker candidates, whereas greater strength mitigated lower endurance.

CONCLUSION
In this SOF cohort, fitness-related dropout and selection success could not be adequately represented by isolated fitness test thresholds. Multidomain Bayesian modeling provided individualized probabilities of selection success and demonstrated compensatory relationships across performance domains. Selection outcomes are therefore better understood as conditional multidomain readiness rather than threshold compliance.

MILITARY IMPACT
Probabilistic multidomain profiling may improve selection preparation by identifying candidates at risk of fitness-related dropout and guiding targeted training interventions. Instead of relying on single performance cut-offs, decision-makers may use individualized probability estimates to guide conditioning strategies and enhance the physical development of operators.

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Thematic 7
Physical Performance tests and readiness indicators

#46784905
Oral Presentation

When One Number Is Not Enough: From Cut-Score Uncertainty to Physical Readiness Zones in Tactical Applicant Testing

BACKGROUND
Established frameworks for physical employment standards (PES) in tactical populations call for a single pass/fail cut-score derived from criterion-referenced task simulation. These frameworks assume the criterion captures physical capacity. In tactical training programs, non-progression is frequently multifactorial. When outcome data are confounded by non-physical attrition (e.g., injury, illness, voluntary release), setting a single threshold cannot be justified. Applying PES-informed methodology to a physical abilities test (PAT) for applicants entering the CBSA Officer Induction Training Program (OITP), this research aimed to convert cut-score uncertainty into physical readiness zones.

METHODS
Phase 1 involved subject matter experts (n=8) in identifying the most physically demanding OITP component, the two-week Control and Defensive Tactics (CDT) course. Phase 2 used structured video observation to characterize CDT demands and inform PAT design (ground-defence, high-intensity agility, and physical control). Phase 3 associated PAT completion time with progression to hiring as a Border Services Officer (BSO) in 625 recruits (29% female; progressed=562; did not progress=63). Discrimination was quantified using receiver operating characteristic (ROC) area under the curve (AUC) with bootstrap 95% confidence intervals (CIs). The Youden index estimated an "optimal" cut-score, and bootstrap resampling (B=1,000) quantified 95% uncertainty. Physical readiness zones were defined as cut-score ± bootstrap half-width. Sensitivity analysis excluded fast but unsuccessful recruits to estimate how non-physical attrition influenced discrimination.

RESULTS
Recruits who progressed were faster (median 182.3 s; IQR 161.0–228.0) than those who did not (median 210.0 s; IQR 174.0–248.0; Mann-Whitney U p=0.003; r=0.23). Discrimination was modest (AUC=0.63; 95% CI 0.56–0.69), consistent with a confounded criterion. The 'optimal' cut-score of 204.5 s (bootstrap 95% CI 159.5–220.5 s) had too much uncertainty to justify a single completion time standard. Instead, physical readiness zones separated recruits into groups with distinct success rates: Green, ≤ 174 s (n=237; 93.7%); Yellow, 174 to 235 s (n=232; 89.2%); and Red, >235 s (n=143; 84.6%). After excluding 26 recruits who were fast yet did not progress, likely reflecting non-physical attrition, AUC increased to 0.82.

CONCLUSION
When outcome data reflect more than physical capacity, the pass/fail framework does not hold. Converting uncertainty into physical readiness zones provides guidance without false precision. Green (likely ready, standard monitoring), Yellow (likely ready, enhanced preparation), and Red (elevated risk, targeted support) replace a binary decision with categories the data can support.

MILITARY IMPACT
Military applicant screening, assessment centres, and early-course standards face the same challenge. Non-completion can reflect injury, course evaluation failure, behavioral or disciplinary issues, administrative decisions, illness, or voluntary release, not physical readiness alone. This work offers a framework when reasons behind unsuccessful outcomes are unavailable. Rather than forcing a pass/fail decision, the framework uses uncertainty to guide preparation, monitoring, and support, so the response to risk is preparation, not exclusion.

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Thematic 7
Physical Performance tests and readiness indicators

#46791860
Oral Presentation

Limits of Physiological Screening in Special Forces Selection

BACKGROUND
Selection of Special Forces operators is intended to identify individuals capable of sustaining performance under extreme physical and psychological stress. Physiological screening is commonly used early in the selection process, yet the extent to which physiological characteristics discriminate between successful and unsuccessful applicants remains unclear. Understanding these limits is critical for optimizing selection strategies in high-intensity conflicts where both performance and adaptability are required.

METHODS
This observational study included 41 applicants to Danish Special Forces selection, of whom 13 were ultimately selected and 28 were not selected. All applicants underwent identical physiological testing prior to selection. Variables included height, body mass, muscle mass, handgrip strength, bone mineral density, maximal oxygen uptake, and total hemoglobin mass. Group differences between selected and non-selected applicants were evaluated using independent-samples t tests or non-parametric equivalents as appropriate, with effect sizes and 95% confidence intervals reported where applicable.

RESULTS
No meaningful differences were observed between selected and non-selected applicants for height (1.84 ± 0.07 vs 1.83 ± 0.09 cm, p = 0.7, effect size = 0.1) or body mass (85 ± 7 vs 82 ± 8 kg, p = 0.2, effect size = 0.4). Muscle mass, handgrip strength, and bone mineral density were similar between groups, with small effect sizes for all comparisons (all p > 0.05, effect size < 0.2). Maximal oxygen uptake did not differ between selected and non-selected applicants in either absolute (4008 ± 479 vs 3952 ± 576 $L \cdot min^{-1}$, p = 0.7) or relative terms (47 ± 6 vs 48 ± 6 $mL \cdot kg^{-1} \cdot min^{-1}$, p = 0.6). Total hemoglobin mass was also comparable between groups (946 ± 115 vs 907 ± 116 g, p = 0.8, effect size = 0.3). Across all measured variables, confidence intervals overlapped substantially between selected and non-selected applicants.

CONCLUSION
Physiological characteristics measured during pre-selection screening did not discriminate between applicants who were selected and those who were not. These findings indicate clear limits to the predictive value of isolated physiological metrics for Special Forces selection.

MILITARY IMPACT
Reliance on physiological screening alone may exclude suitable candidates or provide a false sense of selectivity. Selection systems for high-intensity conflicts should therefore integrate physiological testing with assessments of cognitive capacity, adaptability, stress tolerance, and team function to better identify candidates with true operational potential. Keywords Special Forces, selection, physiology, military performance, screening

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Thematic 7
Physical Performance tests and readiness indicators

#46784986
Oral Presentation

Physical performance changes in a U.S. Army Reserve Command health and fitness pilot program

BACKGROUND
When the U.S. Army established a new physical training doctrine and physical fitness test in 2020, changes were implemented among Active Duty Soldiers first, followed by Reserve personnel. With recognized challenges of execution in a part-time, geographically-dispersed population, the United States Army Reserve Command (USARC) developed a pilot program to support transition to the new doctrine. In 2021, Defense Centers for Public Health–Aberdeen was requested to assist with evaluation of pilot program outcomes.

METHODS
The USARC pilot program consisted of three groups: one comparison group (no additional resources) and two groups that were provided varying levels of health and fitness resources, such as smart phone app-based training, in-person training, and access to unit-level healthcare providers. Evaluation data were collected at baseline (July–December 2021) and during pilot implementation (January–May 2023). Electronic surveys captured baseline and follow-up Reserve Soldier demographics, physical performance, physical training habits, injuries, health behaviors, and health knowledge. Physical performance was determined by results on baseline and follow-up Army Combat Fitness Tests (ACFT) consisting of six events. Changes within each pilot group were assessed using paired samples t-tests. Overall changes between baseline and follow-up performance were assessed using one-way analysis of covariance, with baseline results considered as a covariate. Changes in additional outcomes of interest (physical training, injury incidence, health behaviors, health knowledge) were assessed separately.

RESULTS
Baseline and follow-up ACFT data were available for 1,121 male and 328 female Army Reserve Soldiers in the pilot program, and for five of six matched ACFT events based on administrative changes made to the test during the evaluation. At follow-up, the largest improvements in ACFT event performance occurred in the highest resourced group ($p<0.05$), compared to within-sex groups with fewer resources. Men in resourced groups performed significantly better than those without any additional resources on nearly all events ($p<0.05$), and those without any resources did not perform better than the other groups on any event at either baseline or follow-up.

CONCLUSION
This evaluation suggested that resources introduced as part of USARC pilot programming had a positive impact on physical performance, an important military readiness metric.

MILITARY IMPACT
Results add to growing work documenting effects of enhanced health and fitness resources in military populations.

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Thematic 7
Physical Performance tests and readiness indicators

#46175230
Poster Presentation

Velocity-Based Strength Training (VBT): A Key to Enhanced Warfighter Readiness?

The aim of the session would be to deliver a presentation which considers the potential use of velocity-based strength training (VBT) to individualise the prescription of strength training, at scale, to large warfighter population groups. Utilising either linear position transducer, video, or accelerometer-based technologies VBT can be used to provide real time performance feedback, identify neuromuscular fatigue, asses conditional training readiness, estimate 1 repetition maximums (1RM) and individualise strength training loads. A growing body of evidence is demonstrating that in comparison to traditional strength training prescription methods (i.e., %1 RM), VBT appears to provide an enhanced individualised training stimulus which allows for the true autoregulation of strength training loads. Therefore, this session would aim to define what is VBT, consider its application in a military context, and to review the inherent strengths and limitations of its application.

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Thematic 7
Physical Performance tests and readiness indicators

#46607504
Poster Presentation

The Rise of Pharmacotherapy for Obesity Among U.S. Armed Forces: Trends in Prescribing Prevalence and Implications for Physical Performance and Readiness

BACKGROUND
Obesity among U.S. Service Members (SMs) has reached unprecedented levels, with prevalence surpassing 24% in 2023. Rising obesity prevalence among SMs poses a significant threat to operational readiness and combat effectiveness, contributing to increased musculoskeletal injuries, reduced functional capacity, and potential medical separations. While the Department of War (DoW) expanded coverage for obesity medications (OM) – particularly GLP-1 receptor agonists – in 2018, the impact of these pharmacological interventions on specialized military tasks, muscle mass retention, and effectiveness and readiness in austere environments remains poorly understood.

METHODS
This study analyzes prescription and Soldier demographic data extracted from the Soldier Performance, Health, and Readiness Database (SPHERE) at the U.S. Army Research Institute of Environmental Medicine (USARIEM) from 2018-2024. The aim was to determine the trends in prescription prevalence of obesity medications (OMs) among active-duty U.S. Army Soldiers and evaluate their potential impact on physical performance.

RESULTS
Findings indicate a 600-fold increase the number of total OM prescriptions since 2018 (a 238 fold increase in the number of unique Soldiers), with significant utilization among older personnel and those with comorbid conditions. Phentermine was the most prescribed agent, with a rapid rise in semaglutide (i.e., GLP-1) prescriptions post-2021. Higher prescription rates were associated with males (60%), older age (70% over age 35) non-white races (66%), and enlisted Soldiers (63%). While 72% of prescriptions were for those with a BMI ≥30, usage patterns varied, with 92% of adoptions coming from non-combat occupations. While OMs are effective for weight reduction, initial data suggest rapid weight loss may result in significant sarcopenia and decreased functional strength in some soldiers, potentially impacting load-bearing capabilities and physical performance.

CONCLUSION
The use of OMs is rapidly increasing within the U.S. Army as a strategy to combat obesity, but it introduces, novel, unmeasured risks to combat performance. While reductions in total body mass may improve long-term health, rapid, medication-induced weight loss may lead to unintended degradation of muscle mass and physical performance. Further investigation is required to determine the safety and efficacy of these medications, especially GLP-1 agonists, on physical performance, operational readiness , and retention to ensure they optimize, rather than hinder, the combat effectiveness of the U.S. Armed Forces.

MILITARY IMPACT
This talk will highlight the need for tailored, evidence-informed guidelines for managing medication-assisted obesity treatment to balance health improvements with the high physical demands of combat operations.

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Thematic 7
Physical Performance tests and readiness indicators

#46723796
Poster Presentation

The Identification of Mobility Tests Sensitive to Differences Between Body-Borne Protective Systems

BACKGROUND
Body armour and the integrated load carriage systems are essential for soldier survivability, lethality and sustainability. However, these items can limit mobility and movement performance. Therefore, it is important to understand how system design affects range of motion (ROM) and other critical performance metrics. Currently there are a multitude of testing protocols used by different countries and governing bodies, hindering standardization and between-system comparisons. The purpose of this study is to use state-of-the-art technology to identify which mobility tests are most sensitive to differences between armour and load carriage system designs; thus, facilitating the evaluation of military kits and body-borne protective equipment.

METHODS
Sixteen participants (9 M; 7F) in the Canadian Armed Forces (CAF) performed a series of active ROM tasks, while in a slick condition (i.e., without kit), and while outfitted in 10 different kit configurations. These included soft-armour and full-fighting order (FFO) variations of the current in service (Clothe the Soldier; CTS) and the Dismounted Infantry Capability Enhancement (DICE) kits. All participants performed: trunk flexion and extension (FE), lateral bending (LB), shoulder FE, shoulder abduction and adduction (ABD/ADD), and hip FE. All movements were recorded with a markerless motion capture system (Theia3D, Canada, 40 Hz). Full-body joint angles were extracted for each ROM task. The maximum absolute angles were then identified for each joint across each movement. Linear mixed-effects models were used to examine the effects of condition and movement on ROM, with participant included as a random intercept. Movement sensitivity was quantified using standard effect sizes (Cohen's d), calculated across conditions.

RESULTS
The shoulder ABD/ADD and FE ROM movements were the most sensitive to differences across conditions, demonstrating a moderate sensitivity to changes in kit configurations (d = 0.54, SD±0.49; d = 0.55, SD ± 0.41). Notably, ROM at the shoulders decreased for all kit configurations compared to the slick condition. When comparing CTS and DICE FFO during shoulder ABD/ADD, the CTS kit reduced shoulder ROM by 18.56° (SE = 3.82°), and DICE reduced ROM by only 16.28° (SE = 3.08°). In contrast, during shoulder FE the CTS kit reduced shoulder mobility by 101% when compared to DICE, as the CTS reduced ROM by 20.16° (SE = 4.29 °) and DICE decreased ROM by only 10.03° (SE = 4.90°). Trunk LB and FE were unreliable mobility metrics, as participants often exhibited increases in ROM during these movements depending on where the load was concentrated. Further hip FE had low sensitivity across conditions (d = 0.21, SD ± 0.14).

CONCLUSION
These results suggest that across a variety of kit configurations and two different kit designs, the greatest significance and largest effect sizes between conditions were seen when participants were performing shoulder ABD/ADD and FE. These results suggest that these simple ROM tasks can be recommended for rapid movement-based screening of military-kit performance.

MILITARY IMPACT
The development of standardized screening protocols for the rapid evaluation of military equipment would improve procurement guidelines for body-borne military equipment, achieving balance between coverage, protection, and mobility; thus, improving survivability and performance in the field.

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Thematic 7
Physical Performance tests and readiness indicators

#46777312
Poster Presentation

Physiological Profile of Danish Special Forces Operators: Implications for Human Performance Optimization

BACKGROUND
Special Forces operators are required to sustain physical performance under extreme load, uncertainty, and prolonged high-intensity operations. While selection and training are known to produce highly capable personnel, the physiological characteristics defining successful operators remain insufficiently described relative to the general population, conscripts, and elite athletes. Characterizing these traits is essential for optimizing selection, training, and long-term operational readiness in high-intensity conflicts.

METHODS
This observational study included 37 Danish Special Forces operators. Physiological characteristics were compared with age-matched Danish male population reference data n = 18.065, (1), military conscripts (n = 290) (2, 3), and elite athlete groups selected for high capacity in measured domains (quarterbacks, cross-country skiers and cyclists) (4-6). Group differences were evaluated using independent-samples t tests or non-parametric equivalents as appropriate, with effect sizes and 95% confidence intervals reported where applicable.

RESULTS
Mean height (1.82 ± 0.06 cm) and body mass (86.3 ± 7.7 kg) of operators did not differ from age-matched Danish men ($p = 1$, effect size = 0.00) but were heavier than conscript values ($p < 0.001$, effect size = 0.75). Operators exhibited marked variability in height (coefficient of variation: 3.2%) and body mass (coefficient of variation: 8.9%). Lean mass in operators (67.9 ± 6.6 kg) exceeded population reference values by 11.3% ($p < 0.01$, effect size = 1.06, 95% confidence interval: 0.56 to 1.56) but was lower than that reported for strength-dominated elite athletes such as American football quarterbacks (78.9 ± 5.0 kg). Handgrip strength was higher in operators (60.3 ± 11.2 kg) than in age-matched Danish men (50.0 ± 7.9 kg, $p < 0.001$, effect size = 1.30) and conscripts (49.0 ± 9.3 kg, $p < 0.001$, effect size = 1.19). Bone mineral density (1.38 ± 0.09 $g \cdot cm^{-2}$) exceeded population reference values by 8% ($p < 0.001$, effect size = 1.10) and was comparable to elite strength and power athletes.

Maximal oxygen uptake was high in absolute terms (3738 ± 49 $L \cdot min^{-1}$) and moderate in relative terms (43.3 ± 6.4 $mL \cdot kg^{-1} \cdot min^{-1}$). Both were comparable to population reference values (3660 ± 67 $L \cdot min^{-1}$, $p < 0.5$, effect size = 0.12) but lower than elite endurance athletes such as cross-country skiers and cyclists (77.0 ± 5.6 $mL \cdot kg^{-1} \cdot min^{-1}$, $p < 0.001$). Total hemoglobin mass (10.7 ± 1.4 $g \cdot kg^{-1}$) exceeded relative population reference values by 20% ($p < 0.001$, effect size = 1.29) but remained below elite endurance benchmarks of ~13.5 $g \cdot kg^{-1}$, consistent with the observed aerobic capacity profile.

CONCLUSION
Danish Special Forces operators are characterized by high skeletal robustness, superior functional strength, and moderate aerobic capacity, combined with pronounced variation in body size and composition. These findings indicate that successful operational performance is supported by multiple physiological profiles rather than a single optimal phenotype.

MILITARY IMPACT
Recognition of diverse yet effective physiological profiles have direct implications for Special Forces selection, training, and sustainment. Emphasizing robustness and functional capacity over narrow anthropometric criteria may enhance adaptability and resilience during high-intensity conflicts and prolonged operations. Keywords Special Forces, physiology, military performance, human optimization, operational readiness.

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Thematic 7
Physical Performance tests and readiness indicators

#46786232
Poster Presentation

Perceived Service Member Fitness and Performance Gaps, and Military Task-related Physical Attributes Summary from NSCA's Third Blue Ribbon Panel on Military Physical Readiness

BACKGROUND

The National Strength and Conditioning Association's Tactical Strength and Conditioning Program sponsored the Third Blue Ribbon Panel (BRP) on Military Physical Readiness from 25 to 26 August 2025. The meeting brought together a total of 27 civilian and military subject matter experts (SME) from the United States (U.S.) Air Force, Army, Marine Corps, Navy, Space Force, and academia to discuss the current state of physical performance across the U.S. Armed Services. With policy and program changes regarding military physical fitness since the last BRP meeting in 2013, the current mission was to evaluate, innovate, and recommend comprehensive strategies to enhance the physical readiness of military personnel. This summary covers selected topics discussed by panelists to include perceived gaps related to Service Member fitness and performance, and physical attributes required to successfully complete common military tasks.

METHODS

Similar to SME surveys from two previous International Congress on Soldiers' Physical Performance (ICSPP) meetings, panelists were asked to rate perceived gaps of 43 militarily relevant topic areas on a Likert scale from 1 (Unnecessary, do not consider) to 5 (Largest possible gap); where a "gap" was defined as the need to advance knowledge, guide future resources, and improve the relevance and impact of future efforts. Separately, SME panelists rated the relative importance (1 – lowest, 10 – highest) of 11 health- and skill-related physical fitness attributes required to successfully complete nine common military tasks.

RESULTS

The highest perceived gaps/priorities were: 1) Sleep (4.04/5), 2) Performance of National Guard/Reserve Troops and Physical Demands in Operational Environments (tied; 4.00/5), and 3) Computational/Predictive Modeling of Performance and Musculoskeletal Injury Mitigation Programs (tied; 3.96/5). Compared to survey results from the 2014 and 2017 ICSPP meetings, three topical areas have remained among the top 10 perceived gaps or research priorities over the last 12 years.

Regarding task-related physical fitness attributes, the top three were Muscular strength (7.5/10), Muscular power (6.6/10), and Coordination (6.3/10).

CONCLUSION

SME input identified consistent physical fitness, performance, and readiness gaps within recent years that still need to be addressed. Specifically, Panel ratings indicated that resources should be targeted towards holistic human performance programs focusing on sleep, physical performance, and musculoskeletal injury mitigation, especially in Reserve and Guard units and for those in high-intensity operational environments. Service-wide human performance programs should evaluate the physical requirements of the perceived operational environment through predictive modeling and assign resources to address any deficits in meeting strength, power, and coordination demands for task completion.

MILIARY IMPACT

Findings support military physical readiness policy and program development by identifying strategic targets through which gaps are minimized and human performance is enhanced..

AUTHORS

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Thematic 7
Physical Performance tests and readiness indicators

#46789656
Poster Presentation

Physical Readiness in Candidates for the Danish Special Forces – A Preliminary Study

BACKGROUND
Physical readiness is a critical determinant of performance and risk for injury in military personnel and candidates for special forces. Thus, measurements of strength, balance, and movement may provide valuable insight into the candidates' readiness for the physical demands of elite military training and combat. Therefore, the aim of this study was to assess the strength, balance, and function in the dominant and non-dominant limbs in candidates for the Danish special forces prior entering the special forces basic training program.

METHODS
Twenty-two male candidates (age 26.7 ± 3.8 years, height 185.9 ± 5.2 cm, weight 86.2 ± 6.1 kg) to the Danish special forces were tested to determine handgrip strength, internal and external rotation shoulder strength using a handheld dynamometer, anterior reach assessed by the Functional Movement Screening®, and the single-leg decline squat. Tests were performed on two separate occasions; one test was performed 15 weeks prior to initiation of the special forces basic training program (but after selection to enter special forces training) and the second at four weeks prior initiation of the special forces basic training program. Candidates were for the period between the two tests given advice on improvements based on test performance by an experienced physiotherapist. Students t-test and Wilcoxon signed-rank test were used for statistical analysis.

RESULTS
There was a significant increase in handgrip strength for the non-dominant hand (pre: 61.2 ± 6.1 kg; post: 64.7 ± 6.5 kg; mean difference: 3.5 ± 5.7 kg, 95% CI 1.0-6.0 kg, $p < 0.01$) and in the external shoulder strength (pre: 13.2 ± 3.1 kg; post: 16.0 ± 2.4 kg; mean difference: 2.8 ± 3.4 kg, 95% CI 1.3-4.2 kg, $p < 0.001$) for the dominant arm. No significant improvements were observed in any of the other tests.

CONCLUSION
Improvements during individual preparation before entering special forces basic training were limited to handgrip strength for the non-dominant and external shoulder rotation strength for the dominant limb, while other upper limb strength, and lower limb balance and function remained unchanged.

MILITARY IMPACT
The assessment of physical strength, balance, and functional performance in candidates serves an essential role in ensuring operational physical capacity and to reduce injury risk during demanding training. Assessment of physical strength, balance, and functional performance may help guide individualized training strategies whilst potentially improve training tolerance and sustained performance in high-demand military environments.

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Thematic 7
Physical Performance tests and readiness indicators

#46798258
Poster Presentation

Insights into the new Norwegian short military marching capacity test

BACKGROUND
Current military conscript recruitment tests may not fully reflect load marching (LM) demands, as they assess cardiorespiratory fitness under unloaded conditions. Consequently, the Norwegian Armed Forces developed the Marching Capacity Test (MCT), which incorporates a 25 kg load to better reflect LM demands. This study aimed to identify which physiological and anthropometric components best explain performance variance in the MCT, examine whether associations with MCT performance differ by sex, and interpret these findings in relation to occupational LM demands and current unloaded cardiorespiratory conscript tests.

METHODS
Thirty-two participants (16 females, 23.9 ± 2.1 year, 51.6 ± 7.7 mL · kg-1 · min-1 Relative $\dot{V}O_2$max, 17.8 ± 6.6 % body fat), primarily students with self-reported good physical fitness, completed testing over two non-consecutive days. Assessments included an incremental MCT with 25 kg load performed until exhaustion, a $\dot{V}O_2$max test (absolute, relative, and load-adjusted units), isometric core strength test, maximal countermovement jumps, and anthropometric measurements. Correlation, multiple regression, and stepwise mixed model analysis were conducted to examine associations between physical and anthropometric variables and MCT performance. Independent sample t-tests assessed sex differences across variables, and mixed-model analyses examined whether sex interacted with MCT performance.

RESULTS
Absolute, relative, and adjusted $\dot{V}O_2$max showed strong positive correlations with MCT performance (r = .75, .91, and .92) and explained 56%, 83% and 85% of MCT performance variance, respectively (all $p < 0.001$). The final stepwise multiple regression model retained relative $\dot{V}O_2$max and adjusted isometric trunk flexion strength (ATF). Adding ATF significantly increased the explained variance (ΔR^2 = .033, $p < 0.001$), resulting in a total explained variance of 86.3% ($p < 0.001$). Notably, ATF alone showed a weak, non-significant correlation with MCT performance (r = .29, p = 0.113). No additional variables improved model fit beyond that explained by adjusted $\dot{V}O_2$max alone. Sex did not show an interactive effect upon MCT performance.

CONCLUSION
$\dot{V}O_2$max, particularly when adjusted for body mass and 25 kg external load, was the primary determinant of MCT performance. Despite improving model fit, ATF showed only a weak, non-significant independent correlation with MCT performance, warranting cautious interpretation. Consequently, adjusted $\dot{V}O_2$max remains a more robust independent predictor of MCT performance. Compared with reference conscript data from the 3000-m run (r = 0.65–0.90, R^2 = 0.64) and the MSFT (r = 0.74–0.79, R^2 = 0.72), the loaded MCT showed a stronger association with relative $\dot{V}O_2$max (r = 0.91; R^2 = 0.83) and involves military specific external load, suggesting that it may be a better indicator for occupational LM demands than current cardiorespiratory conscript tests.

MILITARY IMPACT
Informs the development of a LM test that better reflects occupational demands.

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Thematic 7
Physical Performance tests and readiness indicators

#46803490
Poster Presentation

Epidemiology of Injury Incidence of Officer Cadets During Basic Military Training

BACKGROUND
Basic military training exposes officer cadets to repetitive physical loading through activities such as running, field training, and structured physical conditioning. These demands may increase the risk of musculoskeletal injuries, potentially affecting training progression and operational readiness. Objective: This study examined the epidemiology of injuries reported among officer cadets in different consecutive intakes during basic military training.

METHODS
A retrospective review was conducted using injury cases reported to the Sports Medicine Clinic (SMC) from 2019 to 2025. Injury records included mechanism of injury, anatomical location, and diagnosis. Descriptive analyses was performed to identify common injury patterns and mechanisms in all intakes.

RESULTS
A total of 51 injury cases were recorded during the study period. The majority of injuries involved the lower limb, particularly the Achilles tendon, knee, ankle, groin, and plantar fascia. Running-related activities were the most frequently reported mechanism of injury, followed by incidents sustained during field exercises and general physical training. Several cases were associated with overuse conditions including Achilles tendon, plantar fasciitis, and muscle tightness. Interestingly, the injury pattern suggests that injuries peak during the middle phase of the training cycle, particularly around April to June.

CONCLUSION
Lower limb injuries were the most commonly reported injuries among officer cadets during basic military training. Several diagnoses involved overuse of musculoskeletal conditions, such as Achilles tendinopathy, plantar fasciitis, muscle tightness, and groin strain, suggesting cumulative training load as a contributing factor. The findings highlight the importance of monitoring training load, improving terrain risk awareness, and implementing targeted injury prevention strategies focusing on lower limb resilience. Additionally, injury prevention programs should be strategically timed to address increased physical demands during the mid phase of BMT.

MILITARY IMPACT
Understanding injury epidemiology among officer cadets provides actionable insight for military training institutions. Early identification of high-risk activities such as running related training can inform evidence-based program design, injury surveillance systems, and preventative conditioning protocols to reduce injury incidence, maintain training continuity, and support the development of operationally ready officers.

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Thematic 7
Physical Performance tests and readiness indicators

#46806460
Poster Presentation

Laser Biathlon Shooting Test to Objectify the Effects of Total Sleep Deprivation

BACKGROUND
Total sleep deprivation leads to decreased performance in various computer-based cognitive tests. However, it remains unclear to what extent these alterations translate to performance impairments during more complex and operationally relevant tasks. This study presents three Laser shooting tests designed to objectively assess performance in this context.

METHODS
The equipment used included a LV1 Laser Biathlon Rifle from KIWI Précision and a CTOR10 Laser target with five spots. When the target is hit by the laser, it lights up. Shooting was performed in the prone position at a distance of 10 meters from the target. As part of operational fatigue management training courses organized at the National Defence Sports Center in Fontainebleau in collaboration with IRBA, 156 military personnel (mean age 37.8 ± 7.5 years) were included. They completed three types of shooting sequence, each lasting 3 minutes, in the following order: 5 shots with visual stimuli presented behind the target, using two types of card displayed randomly (yellow = “shoot” and red = “do not shoot”), 5 shots with auditory stimuli (whistle), 5 shots with combined visual and auditory stimuli. The time allowed to shoot was 3 seconds. Participants completed three sessions: a familiarization session, a baseline session between 7:30 and 10:00 a.m. after a habitual sleep night (D0), and a session 24 hours later under total sleep deprivation conditions (D1). The score for each shooting sequence was the number of targets hit (th) out of 5.

RESULTS
There was no statistically significant change in performance for shooting with VISUAL stimuli (D0: 3.48 ± 1.37 th vs. D1: 3.41 th, p = 0.34) or AUDITORY stimuli (D0: 3.50 ± 1.46 th vs. D1: 3.62 ± 1.45, p = 0.32). However, there was a significant decline in performance for the combined condition (D0: 3.77 ± 1.25 th vs. D1: 3.50 ± 1.39, p = 0.0359).

CONCLUSION
Lower limb injuries were the most commonly reported injuries among officer cadets during basic military training. Several diagnoses involved overuse of musculoskeletal conditions, such as Achilles tendinopathy, plantar fasciitis, muscle tightness, and groin strain, suggesting cumulative training load as a contributing factor. The findings highlight the importance of monitoring training load, improving terrain risk awareness, and implementing targeted injury prevention strategies focusing on lower limb resilience. Additionally, injury prevention programs should be strategically timed to address increased physical demands during the mid phase of BMT.

MILITARY IMPACT
Understanding injury epidemiology among officer cadets provides actionable insight for military training institutions. Early identification of high-risk activities such as running related training can inform evidence-based program design, injury surveillance systems, and preventative conditioning protocols to reduce injury incidence, maintain training continuity, and support the development of operationally ready officers.

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Thematic 7
Physical Performance tests and readiness indicators

#46812499
Poster Presentation

Comparison of DEXA and Bioelectrical Impedance Analysis Whole-Body Composition Measures in CANSOFCOM Members

BACKGROUND
Reliable body composition assessment supports monitoring of health, performance, and recovery in military personnel. CANSOFCOM members present unique physiological profiles - high lean mass, variable hydration, and demanding occupational requirements - that warrant evaluating measurement techniques within this specific population. Dual energy X ray absorptiometry (DEXA) is widely recognized as a highly accurate method, while bioelectrical impedance analysis (BIA) offers portability and accessibility across diverse military and international settings. Understanding how these tools compare in a high performance military population can help organizations make informed choices based on their operational needs and available resources.

METHODS
A group of CANSOFCOM members (n = 89) completed consecutive whole body scans using the GE iDXA Pro and BIA InBody 570 devices. Fat mass (FM), fat free mass (FFM), and body fat percentage were evaluated using paired t tests, Bland-Altman analyses, and Lin's concordance correlation coefficient. To contextualize measurement variability, precision error and least significant change values for each technology were calculated in a separate reproducibility sample (n = 20).

RESULTS
Significant differences were observed between DEXA and BIA for all variables ($p < 0.001$). InBody underestimated FM by 3.82 kg and body fat percentage by 4.39%, and overestimated FFM by 3.54 kg relative to DEXA. Proportional bias was identified, as underestimation of FM increased alongside FM, similarly for overestimations of FFM. Agreement between the two systems was poor. Precision error analysis demonstrated lower variability in DEXA compared with InBody within this population.

CONCLUSION
Within CANSOFCOM members, BIA systematically underestimates FM and overestimates FFM when compared to DEXA. These differences suggest the two systems should not be used interchangeably for individual level decision making or longitudinal tracking in this population. However, the portability and accessibility of BIA devices mean they continue to provide value in environments where more advanced imaging systems are not feasible. There may be other body composition measurement techniques which provide validity and reliability that should be explored further in comparison to DEXA within these unique populations.

MILITARY IMPACT
Military organizations vary widely in technological resources, logistical constraints, and operational environments. These results can help guide evidence informed decisions rather than prescribe a single approach. Where available, DEXA may offer superior accuracy for applications such as rehabilitation monitoring, complex training interventions, and research requiring high precision data. In settings where DEXA access is limited, BIA remains a practical tool - particularly when used consistently and with awareness of its measurement bias.

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Thematic 7
Physical Performance tests and readiness indicators

#47133837
Poster Presentation

Effectiveness of a Pre-Basic Training Fitness Education Program on Physical Performance in Military Recruits

BACKGROUND
Physical readiness and resilience are critical for successful adaptation to the physical and cognitive demands, sleep restriction, and psychological stress encountered during basic military training (BMT). Previous literature has shown that lower levels of physical fitness are associated with an increased risk of musculoskeletal injuries, which may negatively affect training progression and overall performance. To address this concern, a pre-conditioning program was implemented prior to the commencement of BMT to enhance recruits' physical preparedness. This study aimed to evaluate the effectiveness of a two-week pre-basic training fitness education program (FEP) in improving the physical performance of military recruits.

METHODS
A multi-cohort, non-randomized controlled pre–post study was conducted among newly enlisted male military recruits. The intervention group (N = 393) completed a two-week FEP prior to basic training, while the control group (N = 448) underwent standard entry procedures without doing the FEP. The program comprised structured physical training targeting aerobic endurance and muscular strength and endurance. Educational classes were delivered covering training safety, nutrition, injury management, stress management, and the relevance of sleep in military performance and recovery. Physical performance was assessed using the Recruit Physical Fitness Assessment (RPFA), comprising a 2.4 km timed run, pull-ups, sit-ups, push-ups, and overall pass status. Military swimming competency was evaluated using the Military Swimming Test (MST). Assessments were conducted at baseline (Pre-RPFA and Pre-MST) and at completion of training (Final RPFA and Final MST). Analyses were conducted using available case data.

RESULTS
Significant baseline differences were observed in 2.4 km run, sit-ups, push-ups, and RPFA pass rate (all $p < 0.001$), with the intervention group demonstrating superior initial fitness. For the 2.4 km run, a significant group-by-baseline interaction was observed ($F = 62.076$, $p < 0.001$), indicating that improvements were dependent on initial fitness level. Final average 2.4km run times were comparable between groups (10 minutes 5 seconds). For pull-ups, no baseline difference was detected ($p = 0.381$); however, a significant group-by-baseline interaction ($F = 5.459$, $p = 0.020$) indicated strength adaptation are strongly influenced by baseline performance and completion of the program. For sit-ups, a small adjusted group effect favored the control group ($F = 4.477$, $p = 0.035$, partial $\eta^2 = 0.006$). Moreover, no significant adjusted group effect was observed for push-ups ($p = 0.148$). Final RPFA pass rates were high in both groups (98% in the intervention group; 97% in the control group). Logistic regression demonstrated no independent group effect (OR = 0.791, $p = 0.675$) but revealed a significant group-by-baseline interaction (OR = 12.208, $p = 0.003$). For MST, the intervention group demonstrated significantly higher odds of passing at final assessment (OR = 1.571, 95% CI 1.082–2.283, $p = 0.018$), independent of baseline status. However, no interaction effect was observed.

CONCLUSION
Both groups demonstrated substantial improvements in physical performance during basic training. Aerobic and upper-body strength adaptations were influenced by baseline fitness level. Recruits who completed the pre-basic training fitness education program entered training with higher baseline fitness levels and demonstrated higher final swimming competency. These findings highlighted the benefits of implementing pre-basic training fitness education program in preparing the recruits physically and mentally prior to entering basic military training.

MILITARY IMPACT
A structured FEP combining conditioning with education on safety, nutrition, injury care, stress and sleep may improve recruits' physical readiness and resilience for high-intensity military operations.

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Thematic 7
Physical Performance tests and readiness indicators

#47156002
Poster Presentation

Association between pull-up test performance and body composition indicators in Brazilian Army military personnel

BACKGROUND
Maintaining adequate levels of physical fitness is essential for military operational readiness. Among its components, muscular strength plays a fundamental role in the performance of operational tasks and in the maintainance of the functional capacity required for military duties. Pull-up (PU) test performance, as an indicator of upper-body muscular strength, has important implications not only for operational and physical performance in military populations but also for health outcomes. Higher levels of muscular strength have been consistently associated with more favorable body composition profiles and a lower risk of non-communicable chronic diseases, particularly those related to cardiometabolic health. This work aims to analyze the association between PU test performance and body composition indicators in Brazilian Army military personnel.

METHODS
Observational, cross-sectional study with 331 male military personnel enrolled in a Brazilian Army specialization school (32.0 ± 1.4 yrs.). Body composition parameters body fatness percentage (%BF), body mass index (BMI), body adiposity index (BAI), conicity index (CI), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) were were derived from standardized anthropometric measurements, including body mass and height assessed with a calibrated scale and stadiometer, and waist and hip circumferences measured using a flexible tape. The number of repetitions performed in the PU test was recorded according to the official Physical Fitness Test protocol, which is the standardized assessment used to evaluate the physical readiness of military personnel. Data analysis included descriptive statistics and inferential statistics using Spearman's correlation coeficiente ($p \leq 0.05$).

RESULTS
Significant negative correlations were observed between PU and the body composition indicators. Moderate correlations were found for %BF ($r = -0.5$; $p < 0.001$), WHtR ($r = -0.4$; $p < 0.001$), and CI ($r = -0.4$; $p < 0.001$). Weak correlations were observed for WHR ($r = -0.2$; $p < 0.001$), BAI ($r = -0.2$; $p < 0.001$), and BMI ($r = -0.3$; $p < 0.001$).

When ordered from the highest to the lowest prevalence of cardiometabolic risk, BMI showed the greatest proportion of individuals classified at risk (65.6%, n = 217), followed by BAI (53.8%, n = 178), WHtR (37.5%, n = 124), %BF (27.5%, n = 91), WHR (11.2%, n = 37), and CI (6.3%, n = 21).

CONCLUSION
PU was inversely associated with body composition indicators linked to cardiometabolic risk. Individuals with lower performance in the PU tended to present less favorable anthropometric profiles, particularly higher values of %BF, WHtR, and CI. These findings suggest that PU may serve as a practiccal and accessible field indicator and a complementary tool for monitoring cardiometabolic risk in military personnel.

MILITARY IMPACT
The findings highlight the relevance of upper-body muscular strength as a practical indicator associated with cardiometabolic risk among military personnel. Since the PU test is already part of the Brazilian Army Physical Fitness Test, its performance may serve as a simple and cost-effective field marker to help identify individuals with less favorable body composition profiles. This information may support early screening strategies, guide targeted physical training interventions, and contribute to the maintenance of operational readiness and long-term health in military populations.

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Thematic 8 : Impact of physiological states on brain performance

Le Grand Salon - Mod: C. Verdonk + S. Park

ORAL PRESENTATIONS

Fueling the Mind: How Food and Breath Shape Brain Function and Cognitive Performance

Evaluating the cognitive performance under demanding load carriage scenarios in a virtual reality military-oriented environment – preliminary results

Opposite effects of sleep restriction and moderate hyperthermia on cognitive and neurophysiological markers of arousal

Psychophysiological Readiness Following Mountain Warfare Training in U.S. Marines

Serum Brain-Derived Neurotrophic Factor Responses to High-Intensity Functional Training During Military Service

POSTER PRESENTATIONS

The Effect Military Specific Fast Paced Load Carriage on Cognition in Royal Marines Commandos

A Narrative Review to Inform a Biopsychosocial Model for Understanding Maritime Search and Rescue Task Performance

Preliminary Study: a Flow-First military training architecture for rapid state induction and curriculum conversion to make Flow the core performance regulator

How do different types of fatigue affect physiological measures and cognitive performance?

A Dual Task Framework for Cognitive Performance Assessment During Physically Embodied Military Tasks

Special forces-specific resilience; DHEA-S production capacity differentiates succeeders from drop-outs

Performing Sustainably as a Paris Firefighter Through Health Awareness

Fatigability of task-switching performance under flexible and stable contextual demands

Thematic 8 :
Impact of physiological states on brain performance and resilience

#1000063
Oral Presentation

Fueling the Mind: How Food and Breath Shape Brain Function and Cognitive Performance

PURPOSE
Operational environments place extraordinary demands on rapid decision making, sustained attention, and adaptive cognition. Yet, how body and brain interact, to acutely shape these capacities in real time remains underexplored.
In this contribution, I present recent experimental work investigating how food intake and breathing patterns modulate physiological, metabolic, and neural processes that are critical for decision making and cognitive performance.

METHODS
Across a series of controlled studies in healthy adults, we combined acute nutritional manipulations and targeted breathing protocols with multimodal measurements, including autonomic indices, metabolic markers, and neuroimaging.

RESULTS
We show that specific macronutrient compositions systematically alter arousal, and diverse cognitive functions on tasks, while distinct breathing patterns rapidly shift autonomic balance and decision making.

CONCLUSIONS
These findings support the view that body and brain form a tightly coupled system in which seemingly peripheral variables—meal composition and respiratory patterns—acutely tune neural function and cognitive output.

OPERATIONAL RELEVANCE
These studies have crucial implications for pre mission preparation, in mission regulation, and recovery protocols, and outline how simple, evidence informed adjustments in nutrition and breathwork could be leveraged to enhance decision making, resilience, and performance in military personnel.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46488998
Oral Presentation

Evaluating the cognitive performance under demanding load carriage scenarios in a virtual reality military-oriented environment – preliminary results

BACKGROUND
Military capability relies on integrated physical, cognitive, psychological, and decision-making capacities. In modern operational settings, soldiers must process environmental stimuli, such as visual and auditory cues, and respond appropriately. Physical and cognitive functions share common resources within the central nervous system, so their concurrent activation can produce mutual interference, resulting in both cognitive and physical fatigue. This study investigated the interaction between physical activity, cognitive function, and autonomic nervous system (ANS) responses during operational backpack load marches.

METHODS
Nine male reserve infantry soldiers (aged 21–30 years) with above-average fitness (VO_2 max ≥ 45 mL/kg/min) and prior combat experience completed a three lab visits protocol: one recruitment visit for VO_2 max assessment and two randomized physical effort levels visits. Participants completed 50-minute treadmill walks carrying backpacks at 40% or 60% of heart rate reserve (HRR) in a V-Gait virtual reality (VR) system simulating military terrain. At the start and towards the end of walking cognitive performance was assessed, using military-adapted VR tasks: response inhibition (Go/No-Go, GNG), eye-hand coordination/visual scanning (Catch Game, CG), and spatial orientation/depth estimation (Visual Spatial Processing, VSP).

RESULTS
Cognitive performance revealed task-specific effects of prolonged dual-task exertion. VSP accuracy improved significantly from the start to the end of walking at both effort levels (40% HRR: $p<0.001$; 60% HRR: $p<0.05$), with reduced incorrect responses (40% HRR: $p<0.001$; 60% HRR: $p<0.015$). GNG and CG performance remained stable across time and effort levels ($p>0.05$).

CONCLUSIONS
Our preliminary results underscore the feasibility and useability of a VR and treadmill-based platform to study the effect of exercise of various intensities on cognitive performance. It emerges that learning capabilities in the cognitive domain are preserved during 50 min of demanding load carriage march (i.e., improvement in VSP, and reduction in incorrect responses). These task-specific adaptations indicate that soldiers maintain or enhance spatial processing and coordination during prolonged tactical movement, with preserved executive function.

MILITARY IMPACT
Soldiers' operational capability relies on the interplay of cognitive, motor, and autonomic systems. Understanding these multidimensional dynamics in realistic environments can improve training strategies, and performance optimization under operational stress.

AUTHORS

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46737826
Oral Presentation

Opposite effects of sleep restriction and moderate hyperthermia on cognitive and neurophysiological markers of arousal

BACKGROUND
While on duty, military personnel are exposed to combined stresses, such as sleep deprivation and heat. They must nevertheless maintain a sufficient level of cognition to ensure the success of their missions. The anatomical and physiological links between the neurological structures that control sleep and thermoregulation are well known. Our study aimed to examine the evolution of vigilance, sleepiness and electrophysiological markers of arousal in healthy subjects exposed to moderate hyperthermia, in habitual or restricted sleep conditions, to objectify the possible interactions of these two factors.

METHODS
Twelve healthy men (30.4±7.3 years, mean±SD) were evaluated during two crossover experimental sessions in a bioclimatic chamber. Each session consisted of sequential passive exposure to a thermoneutral condition (TCORE=37.0±0.2°C) followed by an hyperthermic condition (TCORE=38.3±0.2°C). These were conducted either after an habitual night of sleep (>6h time in bed, TIB) or after a night of sleep restriction (<3h TIB). During the thermoneutrality and hyperthermia phases, a 1-minute eyes closed resting-state electroencephalogram (EEG) was performed to calculate the individual alpha frequency (IAF), relative spectral powers (alpha, theta, and beta bands), and the theta/alpha ratio in the frontal and parieto-occipital territories. Then, subjects performed a 10-minute Psychomotor vigilance task (PVT) and completed a sleepiness scale. The fixed effects for sleep and temperature conditions were assessed using a linear mixed model.

RESULTS
Sleep restriction induced an expected effect, with a decrease in PVT speed ($p<0.01$, Cohen's $d=0.23$), and an increase in the number of lapses ($p<0.01$, Cohen's $d=0.44$) and subjective sleepiness ($p<0.01$, Cohen's $d=1.64$). This response was associated with an increased theta power ($p<0.01$, Cohen's $d=0.54$), a decreased alpha power ($p=0.04$, Cohen's $d=0.39$), and therefore an increased theta/alpha ratio ($p=0.04$, Cohen's $d=0.72$) in the frontal territory.
In contrast, hyperthermia induced an increase in PVT speed ($p<0.01$, Cohen's $d=0.44$) and a decrease in sleepiness ($p<0.01$, Cohen's $d=1.04$), with an effect opposite to sleep restriction on EEG markers. This arousal response was also associated with an increase of IAF ($p<0.01$, Cohen's $d=0.33$). No significant interactions were observed for any of the parameters.

CONCLUSION
In our model, sleep restriction and hyperthermia induced opposite effects on arousal, as confirmed by electrophysiological markers, without any interaction. This demonstrates the arousal-promoting effect of heat under certain conditions. These results are limited to short-term exposure and require confirmation through further studies.

MILITARY IMPACT
Counterintuitively, we observed no interaction between two constraints frequently encountered in military settings. These observations, however, need to be confirmed before considering heat as a potential countermeasure to sleep debt.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46761546
Oral Presentation

Psychophysiological Readiness Following Mountain Warfare Training in U.S. Marines

BACKGROUND
Service Members often undergo specialized training programs before being deployed to prepare for the demands of deployment. Understanding how individuals psychologically and physiologically adapt to the stressors of specialized training could provide key insight into the state in which we are deploying Service Members.

METHODS
Mountain Exercise (MtnEx) is a 4-week training program held at the United States Marine Corps Mountain Warfare Training Center meant to train soldiers in climates and terrains similar to future deployment sites. This investigation examined weekly changes in 60 male U.S. Marines (21.7±3.3y, 27.5±3.4 kg/m2) on a battery of psychological (e.g., stress, resilience, grit, hardiness, mood) and physiological (salivary α-amylase, cortisol, testosterone, and dehydroepiandrosterone sulfate (DHEA-S)) measures using generalized linear mixed models. All procedures were approved by appropriate ethics boards.

RESULTS
There were no significant changes in perceived stress, resilience, grit, control, challenge, total mood disturbance, tension, depression, confusion, or vigor. Hardiness (p=0.005) increased from Wk1 (26.5±0.9) to W2 (28.5±0.9; 95% CI: 0.4, 3.7; p=0.008) and one of its components, commitment (p<0.001), increased from Wk1 (8.4±0.4) to Wks 2 (9.4±0.4; 0.3, 1.7; p=0.001) and 3 (9.6±0.4; 0.4, 2.0; p=0.001). Anger (p=0.018) increased from Wk1 (5.8±0.8) to Wk3 (8.3±0.9; 0.2, 4.7; p=0.028), fatigue increased from Wk1 (6.5±0.6) to Wks 2 (8.4±0.6; 0.3, 3.5; p=0.011) and 3 (8.8±0.7; 0.5, 4.1; p=0.006), and esteem increased Wk1 (13.7±0.6) to Wks 2 (15.1±0.6; 0.1, 2.6; p=0.029) and 3 (16.3±0.6; 1.1, 4.0; p<0.001). α-amylase concentrations (p<0.001) decreased from Wk1 (112.0±8.6 U/mL) to Wk2 (89.4±8.3 U/mL; -44.2, -1.1; p=0.036), increased from Wk2 to Wk3 (131.8±9.5 U/mL; 16.8, 68.0; p<0.001), and then decreased from Wk3 to Wk4 (78.4±8.6 U/mL; -80.2, -26.6; p=0.001). Cortisol concentrations (p=0.006) increased from Wk2 (0.16±0.02) to Wk3 (0.22±0.02 µg/dL; 0.0, 0.1; p=0.049) but decreased from W3 to W4 (0.15±0.02 µg/dL; -0.1, -0.01; p=0.015). Testosterone concentrations (p=0.006) decreased from Wk1 (164.7±12.3 pg/mL) to Wks 3 (108.5±14.1 pg/mL; -104.0, -8.5; p=0.012) and 4 (116.0±12.4 pg/mL; -92.1, -5.4; p=0.019). DHEA-S concentrations (p=0.001) increased from Wks 1 (5861.0±441.7 pg/mL,; 73.0, 2630.42; p=0.033) and 2 (5234.2±422.5 pg/mL; 669.0, 3288.0; p<0.001) to Wk3 (7212.7±487.7 pg/mL) but then decreased from Wk3 to Wk4 (5768.7±442.2 pg/mL; -2753.2, =134.9; p=0.023).

CONCLUSION
Commitment, as well as feelings of esteem, anger, and fatigue and concentrations of α-amylase, cortisol, and DHEA-S peaked at Week 3 of MtnEx; however, all returned to near baseline levels by the end of MtnEx. Events during Week 3 may have induced high levels of stress, but left Marines feeling more confident. Testosterone steadily decreased through MtnEx.

MILITARY IMPACT
Although Marines recovered psychologically and physiologically in most areas at the end of MtnEx, they left training with significantly lower levels of testosterone, which could negatively impact future performance during deployment.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46792534
Oral Presentation

Serum Brain-Derived Neurotrophic Factor Responses to High-Intensity Functional Training During Military Service

BACKGROUND
Brain-derived neurotrophic factor (BDNF) is a key regulator of synaptic plasticity, neurogenesis, and stress resilience. Demanding military training characterized by high physical strain, energy deficit and sleep restriction has been associated with reductions in circulating BDNF. However, longitudinal data examining changes in BDNF with structured physical training programs during military service remain limited. Physical exercise has been associated with increases in BDNF, and exercise intensity may influence the magnitude of the response. As high-intensity functional training has been shown to be a feasible and effective training approach for military personnel, the purpose of the present study was to examine its association with changes in circulating BDNF.

METHODS
A total of 127 voluntary male conscripts completed a 19-week military training period and were allocated to an experimental group (n = 64) or a control group (n = 63). The experimental group followed a structured high-intensity functional training program using sandbags, kettlebells and body weight, whereas the control group adhered to conventional military physical training which focused on ball games, running, and calisthenics. Training volume was 46 h for the experimental group and 42 h for the control group. Fasting blood samples were collected at baseline (PRE), at week 10 (MID), and post-intervention (POST). Serum BDNF changes were analyzed using linear mixed-effects models and Tukey's test for between- and within-group comparisons.

RESULTS
A significant group × time interaction was observed for serum BDNF ($p < 0.001$). In the experimental group, BDNF increased from PRE to POST ($p < 0.001$), remaining stable from PRE (32.1 ± 7.3 ng·mL−1) to MID (31.5 ± 6.8 ng·mL−1) but increasing significantly from MID to POST ($p < 0.001$), reaching 39.2 ± 9.3 ng·mL−1. In the control group, BDNF showed a minor change ($p = 0.008$) from MID (28.5 ± 5.5 ng·mL−1) to POST (31.1 ± 8.2 ng·mL−1) but did not differ between PRE (29.9 ± 5.8 ng·mL−1) and POST.

CONCLUSION
Serum BDNF increased during military training in soldiers participating in high-intensity functional training, whereas no PRE–POST change was observed in those following conventional training. The increase in the experimental group occurred during the latter phase of the training period, although the underlying factors for this remain unclear. The delayed elevation may reflect early service-related physiological and psychological stress attenuating initial BDNF responses, with changes emerging only after prolonged training exposure and stabilization of recovery conditions. However, this interpretation remains speculative and cannot be confirmed based on the present data. As circulating BDNF acts as a peripheral biomarker and does not directly capture functional neurobiological outcomes, future research should integrate biomarker assessments with operationally relevant performance to determine practical significance.

MILITARY IMPACT
Military training exposes soldiers to sustained physical and psychological stressors, emphasizing the importance of understanding training-related physiological adaptations. The present findings suggest that structured high-intensity functional training may support favorable adaptations in peripheral BDNF levels, which may be relevant for stress regulation and physiological readiness. Keywords: BDNF, military training, high-intensity functional training, biomarkers, soldiers

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46454875
Poster Presentation

The Effect Military Specific Fast Paced Load Carriage on Cognition in Royal Marines Commandos

BACKGROUND
The high demands placed upon those who operate in ground close combat roles is well established within the literature. The ever-evolving landscape of warfare means not only will the physical requirement of soldiers be greater but the cognitive demand will only increase due to the development of threats and soldiers being given more technology to support situational awareness. Given this, there is little research into the effect of load carriage on cognition, and of the limited research within this area there is little evidence of what occurs at faster paces and higher intensities. The purpose of this study was to investigate the effect of Fast Pace Load Carriage (FPLC) on cognition within trained Royal Marines Commandos.

METHODS
14 Royal Marines Commandos (Age: 23.7±4 Body Mass: 83.2kg±8.1, Height: 178cm ±6.7) performed a FPLC protocol in line with the Physical Employment Standards (4km with 40.5kg in 50 minutes – rest 5 minutes – 4km with 25.5kg in 35 minutes – rest 2 minutes – 7.5m shuttle every 20 seconds for 20 repetitions with 25.5kg and adopting a prone fire position at the end of the shuttle) whilst conducting cognitive testing through the use of a Military Specific Audio N-Back Task (MSANT) during each bout of load carriage and a Patrol Order Recall (POR) task following each bout of load carriage.

RESULTS
MSANT performance maintained throughout the protocol, and displayed no significant change ($x^2[df=5, n=14] = 7.30$, $p=0.199$). POR on the other hand demonstrated a reduction in performance ($x^2[df=2, n=14] = 6.64$, $p=<0.05$), with declines being observed from recalls 1-3 ($r=-0.62$, $p=<0.05$; $z=-2.32$) and 2-3 ($r=-0.55$, $p=<0.05$; $z=-2.05$).

CONCLUSIONS
Cognitive performance was partially attenuated due to FPLC, with the ability to recall information about the patrol being compromised, specifically following bouts of fire and manoeuvre. Therefore demonstrating that at a minimum physical standard there is a degradation in the recall of mission essential information.

MILITARY IMPACT
The findings of this study demonstrates that even at the minimum physical standard with no additional stimuli or fatigue there is a degradation on a soldiers ability to recall orders following fire and manoeuvre which could have drastic implications when applied to an operational environment, especially in high intensity fire fights. These findings should inform commanders for the high potential for decline in cognition of their personnel, specifically recalling information whilst on higher intensity operations.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46659323
Poster Presentation

A Narrative Review to Inform a Biopsychosocial Model for Understanding Maritime Search and Rescue Task Performance

BACKGROUND
Militaries across the globe are responsible for maritime search and rescue (MSAR) operations in everchanging formats and scenarios. MSAR is often conducted in hazardous environments and exposes personnel to concurrent stressful biological, psychological, and social components (biopsychosocial). These components typically are examined in isolation, often overlooking dynamic interactions among biopsychosocial aspects. A better understanding of multi-component demands placed on personnel during MSAR is vital for future improvements in performance, particularly during high-intensity, high-stakes, time-limited operations.

METHODS
Through a narrative review, we propose a MSAR biopsychosocial model combining occupational, medical, and sports and exercise evidence. By adopting a narrative rather than systematic approach, we accommodate the heterogeneity of existing studies and capture a broad spectrum of task demands, component interactions, and methodological nuances.

RESULTS
We identify core biological demands (e.g. casualty handling, boat re-boarding), critical psychological processes (e.g. decision-making, working memory), prevalent environmental challenges (e.g. cold, wind, poor visibility), and acute social implications (e.g. pagers, disturbed sleep, role conflict). Interactions and moderations, such as concurrent biological-psychological tasks bidirectionally impairing performance, highlight concurrent demands placed on personnel, whereby dynamic operations stress human performance beyond typically one- or two-dimensional scenarios.

CONCLUSION
The proposed biopsychosocial model conceptualises MSAR as a property of interdependent components embedded within environmental conditions. The model identifies performance thresholds, demand interactions, and reveals key research gaps, particularly a paucity of social investigations. This framework underscores a necessity for mixed methods, interdisciplinary, externally valid investigations. This holistic biopsychosocial investigation underpins developments of scenario-based training, operational standards, and policy recommendations that reflect accurate occupational demands; these findings can enhance personnel effectiveness, safeguard acute wellbeing, and improve outcomes for survivors, personnel, and families.

MILITARY IMPACT
This model highlights degradations in MSAR performance and personnel wellbeing when under concurrent component stress, particularly pertinent for forces such as the United States Coast Guard. Military organisations can use this information to improve representativeness of MSAR training by including stressors across biopsychosocial and environmental components. Leadership should reflect on this model to evidence that soldier's physical performance is a constituent of biopsychosocial components. Leadership should also note that extended high-intensity deployments, particularly in conflicts scenarios, will exacerbate demands across all biopsychosocial components.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46726885
Poster Presentation

Preliminary Study: a Flow-First military training architecture for rapid state induction and curriculum conversion to make Flow the core performance regulator

BACKGROUND
High-intensity environments require sustained performance, coordination, and moral robustness under uncertainty. Although the Flow state is consistently associated with optimal engagement and performance, it is insufficiently operationalized as a professional, reproducible training outcome. The scientific challenge is to engineer conditions enabling its reliable induction as a measurable and governable training variable. Flow induction combines physical induction, team-level dynamics, cognitive regulation, and physiological support. Operationally, major constraints include absence of additional time, dedicated personnel or material resources and the necessity of daily applicability without a specialized expert. This project aims to shift from conventional "skill-first" models to a "Flow-first" architecture in which state regulation precedes and stabilizes performance acquisition.

METHODS
ADDIE was the instructional systems design model. A comprehensive literature review integrated more than 180 studies and references across Flow research, pedagogy, ethics, professionalization and cognitive-physiological mechanisms. More than 100 individuals from over 30 institutions were consulted to ensure operational relevance. The design mobilized Bloom's revised taxonomy, Roegiers' integration pedagogy, peer dynamics, quality governance models, and contributions from the European Flow-Researchers' Network.

RESULTS
The engineering process produced the following concrete deliverables: - 120 exercises organised into 600 progressive levels for calibrated individual and collective Flow induction; - training frameworks, session planning templates and competence passports for psychocognitive skill tracking; - a conversion matrix transforming existing standard curricula into "Flow-driven" formats, add-in or bolt-in models; - operational Flow governance tools, a formal ethical framework, and safety-of-practice guidelines with no-go thresholds.
No field deployment, empirical measurements, testing, or analyses have yet been conducted. This remains a preliminary engineering phase, deployment and validation trials are scheduled within the current year.

CONCLUSION
This preliminary work is a complete, frugal training framework that professionalises the psyche as a core operational competency and successfully shifts from skill-first to Flow-first logic. Flow induction becomes the central, reliable regulator of performance acquisition, accessible, measurable, and fully integrated without additional time or resources.

MILITARY IMPACT
This framework equips soldiers with immediately usable tools to achieve consistent cognitive, motor, collective and moral performance. At the institutional level, it delivers flexibility and cost reductions by requiring no additional training chain or dedicated resources. Existing programmes can be rapidly converted into Flow-driven formats (add-in or bolt-in). It standardises leadership through a common reference, improves retention and adherence by creating intrinsically motivating experiences. It mitigates psychosocial risks and has built-in ethical and safety safeguards. By repositioning Flow from an incidental by-product to a proximal regulatory mechanism of operational readiness, this frugal and scalable solution professionalises the psyche in order to enhance readiness, effectiveness and provide a new lever in the context of high-intensity engagement.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46737628
Poster Presentation

How do different types of fatigue affect physiological measures and cognitive performance?

BACKGROUND

Military personnel often suffer from fatigue. Causes include sleep deprivation and chronobiological disruption, mental fatigue following enduring task load, under stimulations. As a result of fatigue, performance deteriorates with serious consequences in military settings. Accurate and timely detection of fatigue may alert operators ahead of critical performance decline and provide opportunities for fatigue mitigation strategies. This study aimed to understand to what extent automatically derived signals (EEG, physiological measures and blink characteristics) (1) can distinguish between different types of fatigue and (2) predict cognitive performance during fatigue.

METHODS

Experimental procedures were approved by the TNO institutional review board (reference: 2025-780). In a within-subjects design, 27 healthy volunteers completed three conditions in randomized separate lab sessions over the course of three weeks: 'under stimulation' and 'cognitive fatigue' (performed in the morning and early afternoon) and 'night' (performed at 4 AM after staying awake overnight). Each lab session consisted of a 45-minute Multi-Attribute Task Battery (MATB), which was either easy ('understimulation' and 'night') or difficult ('cognitive fatigue') followed by a cognitive performance battery (including the psychomotor vigilance task (PVT). The PVT was also performed before the MATB. Before and after the MATB participants rated their sleepiness, mental fatigue, boredom and motivation). During each entire lab session, EEG, eye metrics, ECG, skin conductance, and facial expressions were recorded.

RESULTS

In the night condition, participants reported more sleepiness and mental fatigue compared to the other cond itions. In the understimulation condition, boredom was higher and mental effort lower than the other conditions. Mental fatigue ratings did not significantly differ between the understimulation and cognitive fatigue condition. PVT performance deteriorated from pre-to-post tests in all conditions. PVT response time was significantly slower at night compared to the other two conditions. Preliminary analysis revealed that during the MATB, in relative EEG power, parietal alpha (lower and upper bands) was significantly suppressed in the cognitive fatigue compared to underload condition, consistent with relatively high engagement in this condition. No differences for frontal theta (relative EEG power) were observed between conditions. Regarding eye metrics, a higher mean percentage of eye closure (PERCLOS) and slower eye opening was observed in the night compared to the other conditions. No differences in these eye metrics were observed between the cognitive fatigue and underload condition. More results will be presented at ICSPP 2026.

CONCLUSION

The conditions affected the subjective ratings in the expected directions. Objective alertness was most affected by chrono disruption. Preliminary analyses indicate that different types of automatically collected signals have discriminative power to distinguish different origins of fatigue.

MILITARY IMPACT

This work contributes to a basis for physiological fatigue detection among stationary military operators (for example air traffic controllers, surveillance drone operators, and troop commanders working in confined spaces) that are at risk of cognitive performance degradation due to different types of fatigue.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46797415
Poster Presentation

A Dual Task Framework for Cognitive Performance Assessment During Physically Embodied Military Tasks

BACKGROUND
Cognitive performance is critical for soldier performance. Effective decision making and motor control rely on a continuous coupling between sensorimotor input and cognitive processing. As a result, the assessment of brain performance is highly sensitive to the way tasks are sensorily and physically embedded. To support informed decisions on soldier system configuration and operational planning, cognitive performance should therefore be assessed under conditions that reflect sensorily and physically embedded task execution, rather than resting laboratory settings. This study evaluates cognitive performance during physically embodied operational tasks using the Mobile Immersive Cognitive Environment (MICE), a mobile simulation platform in which soldiers walk, navigate, and conduct reconnaissance in a 180° virtual environment. Three cognitive dual tasks—Spatial Stroop, Raven's Progressive Matrices, and an auditory 1 back—were integrated to assess sensitivity to operational scenario complexity and soldier system configuration.

METHODS
Ten active duty soldiers completed eight reconnaissance sweeps varying in scenario complexity (high vs. low) and soldier system configuration (with vs. without auditory detection warnings of enemy sensors). During each sweep, participants navigated through a predefined urban area (physical movement on a treadmill in a virtual environment) with the task objective of remaining undetected by enemy sensors while verbally reporting their location and routes. Concurrently, participants performed two cognitive tasks: one visual task (Spatial Stroop or Raven's Progressive Matrices) and an auditory 1 back task.

RESULTS
Preliminary results indicate that the integrated dual tasks are feasible to administer during physically embodied operational activities. Furthermore, results from the auditory 1 back task suggest that higher complexity scenarios elicit greater cognitive demand than lower complexity scenarios. In addition, the findings indicate that tasks involving prolonged problem solving (Raven's Progressive Matrices; identifying the image that completes the pattern) are more difficult to combine with simpler single question tasks (1 back; same or different letter) than tasks that rely on rapid task switching between brief questions (Stroop; location vs. direction judgments). Ongoing analyses will further examine the sensitivity of the dual task design to soldier system configuration.

MILITARY IMPACT
By embedding cognitive assessment within physically demanding reconnaissance tasks, the MICE platform enables evaluation of cognitive performance under ecologically valid physiological states that approach real world operations. While the current study focuses on cognitive interventions, the approach provides a foundation for evaluating soldier system configurations that directly affect physical or sensorial burden, such as protective equipment, carried load, or environmental stressors. This capability supports more informed decisions in training, doctrine, and soldier system development by capturing cognitive performance in (virtual) military realistic settings.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46809791
Poster Presentation

Special forces-specific resilience; DHEA-S production capacity differentiates succeeders from drop-outs

BACKGROUND
The search to improve the success ratio of the tier 1 qualification course (Q-course) is still ongoing. In our previous work, we demonstrated that, unsurprisingly, physical fitness is a major predictor of success. However, for the first time, we also demonstrated the major influence of intelligence as the most important determinant of success for the qualification course. The present study aimed to explore the construct resilience (i.e., successfully completing the Q-course or not) in further detail by continuing to explore the psychophysiological determinants of success for the qualification course.

METHODS
Twenty-five male military recruits volunteered to participate in this descriptive study in which all measurements took place right before, during or immediately after the Q-course. The Q-course consists of 21 weeks of Special Operation Forces (SOF)-specific military training and testing. The present study focused upon performance measures and self-reported measures of resilience, stress-related blood biomarkers and the genotyping of stress-related Single Nucleotide Polymorphisms.

RESULTS
Performance-wise, both performance on the Bergham run (p=.017) and the land navigation test 1 (p=.012) were found to be linked with SOF-specific resilience (i.e., succeeding or not). Physiologically, only succeeders were found to increase their DHEA-S from pre to post the land navigation test 1 (p=.038). A clear correlation exists between absolute and change score values of DHEA-S concentration and DHEA-S/cortisol ratio on the one hand and performance on the Bergham run and the land navigation test 1 on the other hand. Stable interindividual variability in DHEA-S concentration [intraclass correlation coefficient (ICC)=0.83] and the DHEA-S/cortisol ratio (ICC=0.76) was observed.

CONCLUSION
The physiological markers (i.e., relative changes in and absolute levels of DHEA-S and DHEA-S/cortisol) demonstrate that SOF-specific resilience has both trait and state facets and opens up the opportunity to gain extra insight into SOF-specific physiological resilience via screening and monitoring of DHEA-S concentrations and DHEA-S/cortisol ratio.

MILITARY IMPACT
Screening for performance (as is currently already done in the Q-course with the Bergham run and land navigation tests) and for absolute DHEA-S concentration could in the future be used to identify resilient individuals or those at risk for SOF-specific stress-related performance decrements. Accomplishing this prior to performance under severe stress or the development of clinical stress disorders [e.g., post-traumatic stress disorder (PTSD)] could facilitate focused preparation. Monitoring of state facets such as DHEA-S production capacity also holds value. This monitoring information could be used to finetune the content and structure of the Q-course and multiple military (selection) courses.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#46831868
Poster Presentation

Performing Sustainably as a Paris Firefighter Through Health Awareness

BACKGROUND

In the field of physical skills and bodily techniques, one model dominated throughout the twentieth century: sport. This stems from major transformations within Western societies and from the growing demand for measurement and quantification characteristic of our era. This model has led to an approach to movement focused on strength production, to sidelining health whenever performance takes precedence, and to valuing hyperspecialisation at the expense of adaptability. Although this paradigm is now widely criticised, its influence remains strong: elite athletes continue to embody success, and physical education remains largely centred on sport. This persists despite the shortness of athletic careers and the widespread use of doping—both signs of the model's limits and saturation—even in environments where performance cannot be reduced to record based logic, such as the military. In this context, how can Paris firefighters reconcile operational demands with sustained awareness and management of their health?

METHODS

Before this study, exploratory observations were conducted in two fire stations. They revealed a tendency to overestimate the operational importance of strength at the expense of health, as well as a gap between perceived and actual health, linked to a partially fantasised military culture. These findings informed the development of a semi structured interview guide grounded in field realities. Interviewees were first invited to express their perception of the skills required in their profession. They then completed a "consciousness drawing," a tool designed to reveal their overall wear and tear. They were asked to depict their current health status on silhouettes, freely annotating injuries and recurring aches. This step brought out their perceived state of health. Using this material, they were then questioned about the relationship they make between health and professional skills.

RESULTS

While performance is traditionally associated with limitless commitment, embodied by the motto "save or perish," this vision can prove counterproductive. The interviews will highlight the difficulty of recognising one's own health condition, which evolves with the accumulation of experiences that leave visible traces. They will also show a tendency among firefighters to minimise or deny these impacts, at the risk of reducing the effectiveness of the skills mobilised during interventions. Throughout the interview, participants will express a gradual realisation: their health is severely tested and often relegated to the background in the face of the demands of the job.

CONCLUSION AND MILITARY IMPACT

The results should reveal that a realistic awareness of one's health related limits would allow skills to be used optimally according to the resources actually available, without harming the firefighter's integrity or the accomplishment of the mission. This would constitute a more accurate and more sustainable definition of performance, more compatible with the extended duration of military service since the end of conscription and the levels of commitment and availability required in the context of high-intensity warfare.

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Thematic 8 :
Impact of physiological states on brain performance and resilience

#47157189
Poster Presentation

Fatigability of task-switching performance under flexible and stable contextual demands

BACKGROUND
Adaptability in the face of ever-changing cognitive demands is an essential feature of human cognitive performance. Military operators often have to perform in dynamic and uncertain environments. These environments impose high cognitive demands, notably due to the need to switch between two or more tasks (Chérif et al., 2018). Task switching is associated with a performance cost (i.e., switch cost), manifested by increased response times and error rates (Wylie & Allport, 2000). Various factors can affect this cost, such as switch probability. Switch costs are reduced when switches are more frequent in a block of trials (70% vs 30% switch trials; Siqi-Liu & Egner, 2022). These findings suggest that encountering more switch trials enhances switch readiness in response to contextual demands, presumably due to co-activation of both task representations in working memory (Dreisbach & Fröber, 2019). When prolonged over time, such cognitive demands can lead to a state of mental fatigue (Balkin et al., 2023) and can impair performance and increase errors (Caldwell et al., 2019). Moreover, switching in flexible contexts may rely on the recruitment of cognitive control resources (Pessiglione et al., 2025) to a greater extent than in stable contexts. It is therefore reasonable to question whether flexible contexts (requiring high switch readiness) could involve higher depletion of cognitive control resources and induce mental fatigue more rapidly than a context requiring greater cognitive stability. To test this idea, we examined the dynamics of task-switching performance over time in stable (25% switch trials) and flexible (75% switch trials) contextual conditions.

METHODS
Participants had to switch between two perceptual discrimination tasks developed to mimic the visual processing demands of military environments (Mecheri et al., 2026). Stimuli consisted of a crowd of soldiers wearing khaki or white uniforms, with some soldiers moving coherently in one horizontal direction and others moving randomly. Participants had to discriminate the majority uniform color (color task) or the direction of coherent motion (motion task). Task switching was performed over a prolonged period of time (45 minutes) in two independent conditions: mixed-task blocks with 25% (stable context) and with 75% switch probability (flexible context). Participants had to respond as quickly as possible without scarificing accuracy. Task performance was analyzed using response time (RT), error rate (ER), and switch cost (SC). SC was defined as the difference in RT between “task-switch” and “task-repeat” trials. “Task-switch” trials corresponded to trials in which the task differed from the previous trial. “Task-repeat” trials corresponded to trials in which the task was identical to the previous trial. A desk-mounted eye tracker was also used to record changes in pupil dilatation as an index of cognitive engagement and fatigue.

RESULTS
Data collection is ongoing. The results will be analyzed using average performance metrics (RT, ER) and task-switching costs (SC) over the course of flexible and stable conditions. Pupillometry measures will be used to compare maximum pupil dilation values at various time points over the course of the flexible and stable conditions.

CONCLUSION
The results and preliminary findings of this ongoing study will be presented at the conference.

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Thematic 9 : Challenges for female integration in high intensity conflicts

Salle Lucienne et André Blin - Mod: N. Koulmann + J. Greeves

ORAL PRESENTATIONS

Determinants of physiological demands, physiological resilience, and neuromuscular fatigability during military load carriage in women: an observational trial

Effects of a combined rehabilitation and physical development programme on occupational performance, bone, and tendon health in postpartum servicewomen: A non-randomised controlled trial

Men and women respond differently to military service: A matched paired analysis of baseline physical fitness

Identifying Body Armour Design Features to Support Physical Readiness in Dutch Female Soldiers

Development of an Integrated Women's Body Armour System Using Theoretical and Human Factors Approaches: A Case Study

Bra Requirements for Military Women: Evidence-based Considerations

POSTER PRESENTATIONS

Chest-Related Discomfort and Sports Bra Use in Female Soldiers - A Pilot Study of Health and Operational Performance Implications

Hormonal Contraceptive Use and Associated Health- and Performance Outcomes in German Servicewomen: A Two-Stage Analysis

Body Composition and Physical Performance Changes Among Men and Women Completing 6-months of Reserve Officers' Training Corps Training

Longitudinal Training effect of Postpartum in person programing on Canadian Armed Forces women

Development of a female-specific base-layer for a multilayer cold-weather ensemble

Thematic 9
Challenges for female integration in high intensity conflicts

#46217494
Oral Presentation

Determinants of physiological demands, physiological resilience, and neuromuscular fatigability during military load carriage in women: an observational trial

BACKGROUND
Since the UK Armed Forces opened all ground close combat roles to women in 2018, more female soldiers are carrying heavier loads for longer. Female soldiers typically have lower aerobic fitness, muscle mass, and strength than their male counterparts, increasing the physiological demand and injury risk associated with load carriage. This study investigated associations between gold-standard measures of aerobic capacity, strength, and lean mass and the physiological demands of load carriage in women, and associations between load carriage demands and neuromuscular fatigability.

METHODS
Thirty-nine women (28 ± 4 y) had maximal rate of oxygen uptake (V̇O2max) and body composition (DXA) assessed before completing a load carriage task (12.8 km in 120 min carrying 20 kg). Oxygen uptake (%V̇O2max), heart rate (HR), and ratings of perceived exertion (RPE) were measured during load carriage. Isometric (90° knee angle) and isokinetic (60 and 180·s-1) peak knee flexor and extensor torque were measured before and after load carriage to assess neuromuscular fatigability. Physiological resilience was measured from the decoupling between internal (V̇O2 and HR) and external (pace) workload over time. Associations between V̇O2max (ml·kg-1·min-1), lean mass, and pre-exercise knee extensor function (isometric and isokinetic [60 and 180°·s-1] peak torque) with load carriage demands (%V̇O2max, %HRmax, RPE) and physiological resilience (V̇O2 and HR decoupling) were assessed using simple linear regression. Associations between load carriage demands and physiological resilience with fatigability (absolute change in peak torque) were assessed using multiple linear regression, controlling for pre-exercise peak torque.

RESULTS
Higher V̇O2max was associated with lower %V̇O2max and RPE, and greater HR decoupling during load carriage ($R^2 \leq 0.23$; $p \leq 0.036$). Higher lean mass and isometric knee extensor strength were associated with lower RPE during load carriage ($R^2 \leq 0.18$; $p \leq 0.042$). Only isometric knee flexion declined after load carriage (-8%; mean absolute change [95% confidence interval] = -6.6 [-9.7, -3.5] N•m; $p < 0.001$). Higher %V̇O2max and greater HR decoupling during load carriage were associated with a greater reduction in isokinetic (180°·s-1) flexion peak torque (adjusted $R^2 \leq 0.36$; $p \leq 0.025$).

CONCLUSION
Aerobic capacity, muscle mass, and knee extensor strength are potential targets for interventions to improve load carriage capacity in women. Women were largely resistant to neuromuscular fatigue during load carriage with 20 kg, however, improving aerobic capacity may better preserve neuromuscular function at high operational loads.

MILITARY IMPACT
Women are now operating in the most demanding combat roles in many international militaries. Developing aerobic capacity and strength may reduce the physiological demands of load carriage and protect against neuromuscular fatigue under load, reducing injury risk and improving operational performance.

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Thematic 9
Challenges for female integration in high intensity conflicts

#46367504
Oral Presentation

Effects of a combined rehabilitation and physical development programme on occupational performance, bone, and tendon health in postpartum servicewomen: A non-randomised controlled trial

BACKGROUND
Evidence-based guidance to support postpartum servicewomen in safely regaining occupational fitness while protecting musculoskeletal health is limited. This study examined the effects of an 18-week combined rehabilitation, aerobic endurance, and resistance training programme on occupational performance, pelvic and psychological health, and bone and tendon properties in postpartum UK servicewomen.

METHODS
In this non-randomised controlled trial, servicewomen were allocated at 6 weeks postpartum to an intervention group (INT; n=17) or standard care control group (CON; n=14). CON received standard postpartum care, while INT completed standard care plus core and pelvic floor rehabilitation from weeks 6 to 24 postpartum, and progressive resistance training and high-intensity interval training from weeks 12 to 24 postpartum. Assessments conducted between 6 and 24 weeks postpartum included occupational physical performance tests, pelvic health, psychological well-being, body composition, whole-body and regional areal bone mineral density (aBMD; DXA), tibial bone properties (HRpQCT,) and patella tendon morphology and biomechanics. This study was approved by the Ministry of Defence Research Ethics Committee. Data were analysed using linear mixed-effects models.

RESULTS
Eleven INT and nine CON participants completed all assessments, with high training adherence (96%) and no adverse events reported. Significant group × time interactions favouring INT were observed for occupational performance measures, including mid-thigh pull strength, vertical jump height, and 2 km run time (all p≤0.05; 12.7–14.5% improvements), and body composition, pelvic health, and psychological well-being (all p<0.05). There was no effect of training on whole-body or regional aBMD (p £ 0.100), but trunk and spine aBMD decreased over time in both groups (p ≤ 0.021). There was no effect of training on tibial density, geometry, microarchitecture, and estimated strength (p ≥ 0.151), or patella tendon morphology and maximal biomechanical properties (p ≥ 0.185).

CONCLUSION
An 18-week rehabilitation and physical development programme is safe, well-adhered to, and more effective than standard postpartum care for improving occupational performance, pelvic health, body composition, and psychological well-being in servicewomen. The programme did not affect tibial bone or tendon properties, suggesting that longer duration or more targeted loading may be needed to stimulate these musculoskeletal adaptations postpartum. The reduction in axial aBMD is consistent with the influence of lactation.

MILITARY IMPACT
A structured postpartum rehabilitation and training programme can safely and effectively improve occupational performance, pelvic health, and psychological well-being in servicewomen without adversely affecting bone or tendon health. These findings provide evidence to inform best-practice guidelines for supporting postpartum servicewomen returning to occupational fitness.

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Thematic 9
Challenges for female integration in high intensity conflicts

#46669355
Oral Presentation

Men and women respond differently to military service: A matched paired analysis of baseline physical fitness

BACKGROUND
In general, women begin their military service with lower baseline levels of physical fitness compared to their male counterparts. To date, there are inconsistent findings regarding how physical fitness adaptations differ between men and women during military service. In addition, there appears to be no previous studies utilising match paired analysis of baseline fitness level when comparing training adaptations between men and women.

METHODS
Results from physical fitness (12-min running, 1-min sit-up, 1-min push-up, and standing long jump tests) and body mass index performed in the beginning and at the end of the military service during 2005-2023 were retrieved used from Finnish conscription register The duration of the military service varied between 6 and 12 months. Match paired comparisons (women, n=11 217: men=21 730) and linear regression based on baseline physical fitness and body mass index (BMI) were used to assess the potential for different training adaptations in women and men. The present study was ethically approved by the Finnish Defence Forces.

RESULTS
After match-pairing, the mean±sd baseline values were the following: 2156±300 m for 12-min running test, 33±11 reps/min for 1-min sit-up, 20±11 reps/min for 1-min push-up and 179±22 reps/min for standing long jump. The match-paired analysis including baseline physical fitness and BMI, showed that the median improvement during military service in 12-min running test was 50 and 200 m for women and men, respectively. The respective improvements were 2 and 4 repetitions for sit-up test performance and 3 and 7 repetitions for push-up performance. Women did not improve their standing long jump test performance, while men improved it by 10 cm. The match-paired linear regressions showed similar results. The difference between sexes in aerobic fitness change was 142 meters in the unadjusted model and in the model adjusted for baseline BMI. The adjustment for the change in BMI during military service decreased the difference to 129 meters. The adjustments for baseline BMI or BMI change did not markedly modify the differences between women and men in muscular fitness tests, where the differences in change were 2 reps, 4 reps and 10 cm respectively for sit-ups, push-ups and standing broad jump.

CONCLUSION
Women and men with similar baseline physical fitness levels adapted differently regarding physical fitness during the military service. The lower adaptations observed in women, may indicate that more focus is needed to put on physical performance related factors, such as well-designed training programmes and overall stress and physical loading balance during the service.

MILITARY IMPACT
The findings from the present study do indicate that adaptations to the same military service are lower in women compared to men. From the perspective of combat readiness, it therefore appears that current military service including its physical training programs are not sufficient to train females to meet the most physically demanding standards for occupational specialties.

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Thematic 9
Challenges for female integration in high intensity conflicts

#46802039
Oral Presentation

Identifying Body Armour Design Features to Support Physical Readiness in Dutch Female Soldiers

BACKGROUND
Body armour is essential for soldier protection and operational effectiveness. As the proportion of female military personnel increases, the need for protective equipment tailored to female body dimensions becomes increasingly critical. However, most existing body armour systems have been developed and tested primarily on male populations, resulting in poor fit for female users. Ill-fitting body armour can lead to discomfort, restricted mobility, and impaired physical performance, factors that directly affect combat readiness. Despite these concerns, the specific design requirements for female-focused body armour remain insufficiently understood. The objective of this study was to identify which specific body armour design features best support usability, comfort, mobility and physical performance in female soldiers by evaluating four types of body armour (A, B, C, and D).

METHODS
Seventeen operationally active Dutch female soldiers participated in a randomized, within-subject controlled mobility study. Each participant tested all four body armour configurations (A–D) while performing a series of standardized military tasks, including the Load Effects Assessment Program (LEAP) obstacle course, a 1.5 km loaded march, shooting drills, vehicle egress, and range-of-motion (ROM) exercises. Objective outcome measures (obstacle completion times and ROM) and subjective evaluations on seven aspects (mobility, physical performance, comfort, usability, compatibility, perceived protection and robustness (scale 1 to 10) and identification of design features) were collected for each configuration. Data were analyzed using repeated-measures ANOVA or Friedman tests, with significance set at $p<0.05$.

RESULTS
Mobility was ranked as the most important aspect by the participants (8.6 ± 1.4), followed by physical performance (8.5 ± 1.0), comfort (7.4 ± 1.2) and usability (7.3 ± 2.0). Design features that improved mobility, comfort and usability, such as lighter weight, shorter length, flexible materials, low cut-outs armpit region, elastic inner waistbands, and easily adjustable straps, were strongly preferred. Participants completed the LEAP obstacle bounding rushes faster (C: 42.7 ± 9.1 s & D: 42.3 ± 7.4 s vs A: 47.9 ± 9.1 s, $p<0.01$) and had greater seated reach ROM ($p<0.05$) when wearing reduced-bulk, better-fitting configurations (C: 43.3 ± 3.9 cm; D: 44.4 ± 4.4 cm) compared with the bulkier configuration (A: 41.4 ± 4.4 cm)), confirming a link between subjective preference and objective performance. Conversely, features like excessive bulk and heavy weight, multi-layered construction were associated with lower mobility and comfort ratings, as well as significantly slower obstacle times and more constrained ROM.

CONCLUSION
During this evaluation of four types of body armour specific design features for enhancing mobility, physical performance, comfort and usability were identified. Configurations that minimize bulk and incorporate ergonomic fitting elements, such as lightweight materials, elastic inner waistbands, flexible design, allowed greater freedom of movement, higher comfort, and improved task performance relative to bulky, stiff, multi-layered designs. These findings provide evidence-based design recommendations to guide the development of next-generation female body armour with better anatomical fit.

MILITARY IMPACT
Deploying body armour optimized for female soldiers directly supports physical readiness by improving mobility and comfort during task-critical activities. With an enhanced fit, female personnel can move faster, carry loads more efficiently, and sustain performance. Adopting these design improvements could enhance combat readiness, reduce injury risk associated with poor fit, and ensure all soldiers, regardless of gender, can perform to their full potential.

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Thematic 9
Challenges for female integration in high intensity conflicts

#46809256
Oral Presentation

Development of an Integrated Women's Body Armour System Using Theoretical and Human Factors Approaches: A Case Study

As female representation in armed forces aims to increase, and as barriers for women in close-combat roles are reduced, limitations of body armour designed for male anthropometry have become increasingly evident. Poor fit negatively affects comfort, mobility and protection, and may impact operational performance. This study presents an iterative design and validation process used to develop an integrated body armour system for women, integrating a carrier, soft armour inserts, and hard armour plates.

Female-specific hard armour plates have recently been developed by several reputable suppliers. One set of such plates were acquired and their geometries theoretically validated using bivariate accommodation analyses aiming to cover more than 95% of the reference population (UK military anthropometric data from a 2024 pilot study was used). Three critical body measurements as well as self-assessed bra size and their corresponding product dimensions were identified: chest breadth-plate width, suprasternal notch to 10th rib distance-plate length, suprasternal notch to iliac crest distance-plate carrier length and bra size-plate curvature. Physical fit validation was conducted with 42 participants selected to represent the chosen user population, including representation of extreme percentiles (including one woman with chest breadth over 99th percentile and bust sizes up to cup size L). The hard plates were placed on each participant's torso in standing and sitting postures, to validate coverage requirements. In parallel, three full body armour system prototypes were developed and assessed for comfort, coverage and mobility in standing, sitting, kneeling and prone positions, and during rifle shouldering.

Theoretical analysis, supported by physical testing, showed that the plate size range met the critical fit criteria for all of the anthropometric data, with considerable overlaps between accommodation boundaries of adjacent sizes. Human Factors assessments revealed systematic low plate positioning, linked to bust volume being designed too high on the hard plate component. In the prone position, excessive pulling of the armour carrier at the neckline occurred when the plate bust volume was insufficient. Analysis indicated that this was caused by plate tilting due to abdominal contact. Increased rifle-shouldering stability was observed with the prototypes, which provided reduced soft-armour coverage at the armscye compared with typical ESAPI plate carriers.

These findings led to moving the bust volume lower on the hard plate geometry. Size cutoffs were refined to eliminate size overlaps, to improve size-selection reliability. A size-recommendation algorithm incorporating length, width and bust variables was established. The methods enabled the development of an appropriately sized, integrated women's body armour system through theoretical analysis, iterative design loops and Human Factors validation. Progressive system-level integration and evaluation of operational postures were critical to achieving robust fit and functional performance for the target population.

This work supports improved protection, comfort and fit for female soldiers. The method provides a practical framework applicable to the development of armour systems for specific soldier populations and applicable to other multi-component, sized military equipment.

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Thematic 9
Challenges for female integration in high intensity conflicts

#46695821
Oral Presentation

Bra Requirements for Military Women: Evidence-based Considerations

BACKGROUND
Females frequently report breast discomfort and bra related issues during physically demanding military training. Breast support is a critical component of individual equipment for servicewomen, particularly as efforts continue to increase female recruitment into armed forces. It was hypothesised that commercial sports bras, typically designed for short duration exercise, may not be suitable for the unique physiological and biomechanical challenges imposed by military tasks. A task specific evaluation was undertaken to ensure that breast support provisions adequately address biomechanical, environmental and operational demands.

METHODS
A multi study mixed methods programme assessed bra suitability across the duration of British Army Basic Training (BT). Study 1 (n = 236) used questionnaires and interviews with recruits and training staff to characterise breast demanding tasks, patterns of bra use and the effectiveness of the existing fitting and issue service. Study 2 (n = 25) examined four issued bras in controlled simulations of running, loaded marching and high impact military movements, using breast biomechanics, thermal measures and perceptual ratings. Study 3 (n = 93) monitored the same four issued bras in long duration field use over 14 weeks of BT, capturing weekly experiences of support, comfort, equipment interaction and evolving preferences, supported by end of course focus groups.

RESULTS
Despite professional fitting, 60% of recruits reported breast or bra problems during BT, with issues including chafing, strap discomfort, poor support and interference with torso-borne equipment. Laboratory data demonstrated substantial variation in breast movement reduction between designs (44% to 62%; $p < 0.001$). Field monitoring during BT confirmed that suitability changed with task type, environmental conditions and duration of wear.

High support combination designs were favoured for intense physical training, while softer, more compliant styles were preferred during prolonged load carriage or extended field exercises. Several essential bra characteristics were identified, including support level, strap configuration, padding, adjustability, thermal behaviour, ease of donning and compatibility with torso-borne equipment.

CONCLUSION
Current commercial sports bras do not meet the diverse and prolonged demands of military training; the hypothesis was accepted. No single bra was suitable for all tasks; rather, targeted combinations of design features are required to optimise support and comfort across varied operational contexts.

MILITARY IMPACT
Implementing evidence based bra characteristics can reduce breast discomfort, minimise distraction and improve performance and wellbeing. These findings provide a transferable framework for developing task appropriate, military specific bras and for informing procurement, training policy and equipment integration across defence and other arduous occupations.

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Thematic 9
Challenges for female integration in high intensity conflicts

#46658317
Poster Presentation

Hormonal Contraceptive Use and Associated Health- and Performance Outcomes in German Servicewomen: A Two-Stage Analysis

BACKGROUND
Hormonal contraception (HC) is frequently used by servicewomen in allied armed forces and has been discussed as a potential modifier of health, performance, and bone-related outcomes. However, data on contraceptive practices and their physiological implications among German servicewomen remain scarce.

METHODS
Two consecutive projects were conducted. First, a nationwide online survey assessed contraceptive use and underlying motivations among 2747 female soldiers of the German Armed Forces (33.8 ± 8.4 years; BMI 24.2 ± 7.0 kg/m²). Second, an independent sample of 215 servicewomen was recruited, whose distribution in terms of contraceptive methods was similar to that of the survey participants. They underwent physiological assessments, including quantitative ultrasound-derived bone quality, handgrip strength, hemoglobin concentration, and body composition. To analyze the impact of contraception on health and performance, participants were grouped by contraceptive category: combined oral contraceptives (COCP), progestin-only pills, hormonal intrauterine devices, and non-hormonal methods.

RESULTS
In the survey, 38 % of respondents reported current HC use. COCPs were the most frequently used method (13.9 %), followed by hormonal intrauterine devices (7.8 %) and progestin-only pills (7.4 %). Long-acting progestin injectables or implants were virtually absent. Average duration of HC use was 4.0 ± 3.8 years. HC choice significantly varied by age group, indicating higher COCP prevalence in women aged <30 and increasing prevalence of intrauterine devices in those aged >30 years. Underlying motivations for HC use comprised pregnancy prevention (46 %) and management of pain (28 %) and bleeding (21 %). Participants in the second project showed an almost identical distribution of contraceptive methods and revealed no significant differences in bone quality, muscular strength, hemoglobin, or body composition across contraceptive categories.

CONCLUSION AND MILITARY IMPACT
Hormonal contraceptive methods are used by just over a third of female German soldiers, indicating a critical attitude toward HC, with motivations extending beyond pregnancy prevention. Notably, progestin-depot formulations associated with potential adverse health effects appear to be rare, which contrasts with reports from the UK Armed forces . From a military perspective, the lack of significant differences in health or performance-related outcomes across commonly used contraceptive categories suggests that the method of contraception used is not a relevant risk factor in German servicewomen. Health protection efforts may be more effectively directed toward other modifiable risk factors, such as nutrition, energy availability, and training load management, rather than contraceptive use.

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Thematic 9
Challenges for female integration in high intensity conflicts

#46736960
Poster Presentation

Body Composition and Physical Performance Changes Among Men and Women Completing 6-months of Reserve Officers' Training Corps Training

BACKGROUND

United States Reserve Officers' Training Corps (ROTC) is one pathway to enter military service during college. Since poor physical fitness and unfavorable body composition have been associated with reduced military training performance, which sex may impact, ensuring ROTC cadets are physically prepared before graduation is crucial. The purpose of this investigation was to compare regional body composition changes between sexes and examine associations between changes in body composition and neuromuscular performance across 6 months of ROTC.

METHODS

DXA assessed regional body composition (legs, trunk, total) in 96 (women n=37; age=19 [19,21], height=1.7±0.1m, body mass=73.5±11.2kg) ROTC cadets who performed countermovement jump (jump height, modified reactive strength index (mRSI)) and isometric mid-thigh pull (peak vertical force; N/Kg) on force plates at three timepoints (pre, mid, post) during the academic year. Linear mixed effects models with sex, time, and sex*time as fixed effects and participant-specific random intercepts determined regional body composition changes (Bonferroni adjusted). Spearman's correlations examined associations between absolute changes in regional body composition and performance outcomes within sex. Independent samples t-tests (mean±SD) or Mann Whitney U-tests (median [Q1, Q3]) compared cadet characteristics between sexes. The University of Pittsburgh IRB (#21020044) and US Army Medical Research and Development Command (E03018.1a) approved data collection.

RESULTS

Men were older (p=0.009), taller (p<0.001), and heavier (p<0.001) than women, with similar BMI. No sex*time interactions occurred for any body composition outcome. Men had greater lean soft tissue and total mass in all regions except legs (p£0.001). Women had greater fat mass and body fat percent (p£0.001) than men. Pre to mid: body fat percent and fat mass increased (all regions p<0.001); lean soft tissue decreased in leg (-0.15kg; p=0.025), trunk (-0.44kg; p=0.001), and total (-0.60kg; p=0.001). Mid to post: body fat percent decreased in leg, trunk, and total (p£0.033); lean soft tissue increased in leg (0.16kg; p=0.024) and total (0.44kg; p=0.013). Pre to post: no changes. In men, higher jump height was associated with reduced leg fat mass from mid to post (r=-0.40, p=0.034). In women, greater leg lean (r=0.51, p=0.010) and total mass (r=0.45, p=0.022) were associated with greater mRSI; greater trunk (r=-0.64, p=0.001), total fat mass (r=-0.50, p=0.013), and trunk (r=-0.51, p=0.012) and total body fat percent (r=-0.51, p=0.011) were associated with reduced relative peak vertical force from mid to post.

CONCLUSION

The first three months of ROTC training observed fat mass gain and lean soft tissue loss, though all outcomes recovered to pre-levels by the end of the 6 month monitoring period. Increased leg leanness in in both sexes and total and trunk fat management in women may relate to improved performance.

MILITARY IMPACT

Monitoring body composition and performance over long periods may miss granular changes in ROTC cadets. The first three months of ROTC showed unfavorable body composition shifts that recovered in the subsequent three months. More frequent monitoring and structured physical training should be implemented to attenuate transient performance declines and adverse body composition changes, while optimizing preparedness before commissioning and advanced military training.

AUTHORS

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Thematic 9
Challenges for female integration in high intensity conflicts

#46764355
Poster Presentation

Longitudinal Training effect of Postpartum in person programing on Canadian Armed Forces women

BACKGROUND

The Canadian Armed Forces (CAF) Prenatal Postpartum Program (PNP3) is delivered by certified exercise physiologists and designed by the Canadian Society of Exercise Physiologists, open to approximately 400 CAF women on maternity/parental leave yearly. The goal is to provide evidenced based physical training reducing future musculoskeletal injuries, and prepare women for return to duty, including their annual operational fitness evaluation (FORCE). Ultimately, increasing the representation of women in the CAF.

METHODS

Eligible CAF women can access 2x60 minutes sessions per week, with childcare/inclusion of the infant, starting as early as 6 weeks postpartum, after participants have had their 6-week postpartum general practitioner check, until 78.3 weeks postpartum. Research participants complete an MSKi survey, food frequency questionnaire, and physical fitness measures: InBody 570 body composition testing, 6-minute walk test (VO2max) and maximal Isometric Mid-Thigh Pull (IMTP) testing every 3 months.

RESULTS

Sixty-four participants performed at least one testing session across 3 locations (CFB Ottawa, CFB Petawawa and CFB Valcartier). Of these, 27 went on to complete a second trial; and 20 of these also completed their annual occupational fitness evaluation (FORCE) upon return to work. Results of physical fitness metrics demonstrate trends toward improvements for IMPT, predicted VO2max, and positive changes in body composition (weight loss). FORCE data demonstrates the 20 returning CAF women successfully completed the evaluation, with 45% improving from pre-pregnancy scores, and 40% maintaining pre-pregnancy scores. Locations with significant improvements were CFB Valcartier and CFB Petawawa who have had pre-existing Pre/Post natal exercise programs for over 5 years. With Women's Wellness funding CFB Ottawa began delivering PNP3 in 2023, however this program did not demonstrate significant outcomes. In CFB Valcartier and CFB Petawawa, participation data was provided allowing future comparison between frequency of attendance and effect on fitness.

CONCLUSION

Further analysis regarding frequency of participation and the subjective data collected will provide more information on the impact of the program in CFB Valcartier and CFB Petawawa. These data do not exist for CFB Ottawa and the reduced impact of PNP3 in this location may be a result of participation, the population, or the program delivery itself.

MILITARY IMPACT

The fitness metrics provided participants with valuable information on modifiable characteristics such as lower body strength and aerobic capacity which are associated with injury risk. The improvements of these, as well as the success on FORCE demonstrate the PNP3 programming is providing positive benefits in CFB Valcartier and CFB Petawawa. These results provide guidance on how PNP3 practices may be standardized nationwide for all CAF members.

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Thematic 9
Challenges for female integration in high intensity conflicts

#47054253
Poster Presentation

Development of a female-specific base-layer for a multilayer cold-weather ensemble

BACKGROUND

Currently, women make up 17.3% of the French Army, ranking it fourth worldwide in military gender integration. Men and women have different anatomical and thermophysiological characteristics. In this context, it is essential for military personnel to be properly equipped for cold environments. This study aims to design a comfortable, female-specific cold-weather uniform tailored to the needs of its wearers using a 3D methodology, while ensuring protection against extreme conditions cold.

METHODS

The base layer was designed following an analysis of the anatomical and thermophysiological differences between genders. A volunteer mannequin was scanned in multiple postures to gather measurements and create a 3D model, enabling the construction, simulation, and later manufacturing of the garment. The scan in the standard upright posture served as the basis for a 3D garment structure, from which individual components could be designed. The garment construction complies with ISO 7250 and ISO 8559 standards. The fit of the structure can be adjusted for different body regions; for a close-fitting garment, it is set to a negative value. Areas of the garment made with closed-knit fabric (jersey) are designed to provide insulation against the cold, while open-knit sections (mesh) facilitate moisture removal. The fabric used is a blend of wool and synthetic materials. The garment was tested on a thermal mannequin in a climate-controlled chamber with environmental conditions set at 20°C, 50% RH, and an air velocity of 1.8 m/s. The tests followed ISO 9920 and ISO 15831 standards. Additionally, men's base layer garments were tested to perform a comparative analysis.

RESULTS

The 3D design process enables the creation of a garment that fits the mannequin perfectly. The thermal insulation for the female base layer is 0.144 $m^2 \cdot K \cdot W^{-1}$. The male base layers exhibit thermal insulation values ranging from 0.145 to 0.157 $m^2 \cdot K \cdot W^{-1}$.

CONCLUSION

The 3D garment creation method enables the production of clothing that fits the wearer's body perfectly. This approach can be repeated with additional scans or adapted using parametric mannequins. The tested base layers show thermal insulation results of similar magnitude. The next step will involve assessing the comfort of the ensemble under real-world operating conditions.

MILITARY IMPACT

The current French military equipment is unisex and therefore poorly suited to female morphology. Discomfort caused by ill-fitting uniforms negatively impacts female military personnel and their performance. Developing equipment that accounts for anatomical and thermophysiological differences will improve troops' operational capability.

AUTHORS

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Thematic 10 : Thermoregulation in hot environments

Salle Lucienne et André Blin - Mod: P-E. Tardo Dino + K. Levels

ORAL PRESENTATIONS

Heat acclimation with blood flow restriction improves cognitive-motor dual-task ability and neuromuscular fatigue in trained athletes

Physiological and Biochemical Responses of Well-trained Military Personnel in a Multi-Day High-Intensity Training Course

Heart Rate-Prescribed Heat Acclimation Under Protective Equipment: A Field-Deployable Strategy to Sustain High-Intensity Military Performance

Influence of moisture dynamics on microclimate temperature in protective clothing

Kidney Under Load : Strain or Sustain ?

POSTER PRESENTATIONS

Cognitive-motor dual-tasking under heat stress: performance, perceptual and neuromuscular fatigue responses in athletes

From Forecast to Force Protection: iClim for Risk Management and Prevention of Heat and Cold Weather Injuries at the Commander’s Fingertips

Thermal strain during arm and leg exercise in multi-layer fully encapsulated whole-body protective clothing

Morphological and biological characteristics of heat intolerant individuals in a military cohort

Thermoregulation in hot environments

Thematic 10
Thermoregulation in hot environments

#1000054
Oral Presentation

Heat acclimation with blood flow restriction improves cognitive-motor dual-task ability and neuromuscular fatigue in trained athletes

BACKGROUND
This study examined whether heat acclimation (HA), and HA with blood flow restriction (BFR) could attenuate cognition and neuromuscular function impairments in cognitive-motor dual-task (CMDT) during exercise-heat stress.

METHODS
Twenty trained adults were randomly assigned to one of two HA protocols over six sessions (~8 days). Each session consisted of 4×8-min self-regulated cycling intervals (5-min "strong effort", 3-min "moderate effort") in temperate conditions (20°C), immediately followed by 40-min hot water immersion (40°C). One group exercised with BFR during the "strong" bouts (50% arterial occlusion pressure; BFRHA), whereas the control group completed without occlusion (CTRLHA). Before and after HA protocols, participants completed an exercise-heat stress test with CMDT (pre- post-HA; 40°C, 40% relative humidity): 1×7-min self-regulated cycling ("strong effort") followed by 2×7-min fixed-power blocks with an attentional task. Heart rate, rectal temperature, and mental effort were recorded, while neuromuscular function (peripheral, central responses) was assessed post-CMDT during a 1-min sustained maximal contraction. Data were analysed using repeated-measures analysis of variance and are presented with 95% confidence intervals (CI), and effect sizes (Cohen's d).

RESULTS
During HA sessions, heart rate and rectal temperature were comparable between groups (P≥0.19), despite a reduced power during BFRHA by 17±5% (95%CI [-22, -12]; d=2.7; P<0.001). Post-HA, both groups reduced (P≤0.003) peak heart rate (CTRLHA: -5±4 bpm, BFRHA: -7±6 bpm) and rectal temperature (CTRLHA: -0.19±0.15°C, BFRHA: -0.15±0.12°C). Both improved attentional performance by 10±5% (95%CI [6.1, 15]; d=0.89; P<0.001) with decreased mental effort by 12±6 a.u. (95%CI [-19, -5.3]; d=0.83; P=0.002). Force loss was evident only in BFRHA post-HA (+18±12%; d=0.74; P=0.001), consistent with greater central activation by 17±12 (95%CI [0.3, 34]; d=1.0; P=0.048) versus pre-HA.

CONCLUSION
Effective heat adaptations were induced by both HA protocols, despite the lower workload with BFR. Both approaches enhanced sustained attention during an exercise-heat stress with CMDT, while BFR additionally mitigated central fatigue.

MILITARY IMPACT
Combining short-term heat acclimation with BFR confers additional advantage by improving thermal tolerance and cognitive awareness while mitigating central fatigue, which may be critical for maintaining safety and minimising the risk of lethal outcomes in high-stress combat situations.

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Thematic 10 : Thermoregulation in hot environments

#46489767
Oral Presentation

Physiological and Biochemical Responses of Well-trained Military Personnel in a Multi-Day High-Intensity Training Course

BACKGROUND
Consecutive days of high-intensity military training impose major physiological and biochemical demands on personnel, heightening risks for exertional heat stroke (EHS), exercise-associated hyponatremia (EAH) and exertional rhabdomyolysis (ER). These illnesses are potentially fatal, but much of the existing evidence is derived from case reports or from single-day/shorter exposure periods. Therefore, we aimed to characterise continuous body core temperature (Tc), biochemical responses and illness risk profiles during a 5-day training course in a warm-humid environment. As a secondary aim, we evaluated the potential of creatine kinase-myocardial band (CKMB) as a field-based proxy for creatine kinase (CK) in assessing ER risk.

METHODS
Twenty-three well-trained male military personnel were recruited. Tc and wet-bulb globe temperature (WBGT) were continuously monitored. Venous blood was collected Pre, Mid, Post and three weeks post-course (Post2). Serum concentrations of sodium, calcium, potassium, chloride, bicarbonate and urea were analysed at Pre, Post and Post2. CK and CKMB concentrations were determined at all four time-points. The relationship between CK and CKMB was analysed using correlation, linear regression and Bland-Altman analyses.

RESULTS
Mean WBGT was 27.3±2.8°C (23.9 – 37.8°C) during the training course, with WBGT ≤ 30.9°C observed 88% of the time. Mean peak Tc was 39.5±0.5°C (38.8 – 40.9°C). 26% of participants had overall peak 39.5 < Tc ≤ 40°C and 17% > 40°C, but EHS was not observed. 48% of participants developed asymptomatic EAH (post sodium concentration<135 mmol/L; 131±3 (126 – 134) mmol/L). Compared with Pre (472 ± 796 U/L, all participants had elevated CK concentrations at Mid (19630±8784 U/L, p<0.001) and Post (12664±7377 U/L, p<0.01). Although CK increased by up to 45-times relative to Pre, ER was not observed. CK and CKMB were strongly correlated (r=0.759, p<0.001), but large individual variability limits the use of CKMB as a proxy for CK (mean bias=0.45 U/L, 95% limits of agreement = -11426 to 11425 U/L). 30% of participants had peak Tc > 39.5°C, post sodium concentration < 135 mmol/L and peak CK > 1000 U/L, forming a 'triple-risk' subgroup.

CONCLUSION
Well-trained military personnel can sustain high Tc (>39.5°C) and large biochemical perturbations (e.g., creatine kinase > 40,000 U/L) during a 5-day high-intensity training course without developing clinical exertional heat-related illnesses, exercise-associated hyponatremia, or exertional rhabdomyolysis, indicating substantial physiological resilience. Subgroups of participants meeting multiple risk thresholds highlight individual susceptibility despite overall cohort resilience.

MILITARY IMPACT
These results support refining safety thresholds to distinguish between expected training responses and clinical risk, and the need for individualised risk assessment to optimise safety and performance.

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Thematic 10 : Thermoregulation in hot environments

#46706907
Oral Presentation

Heart Rate-Prescribed Heat Acclimation Under Protective Equipment: A Field-Deployable Strategy to Sustain High-Intensity Military Performance

BACKGROUND
Military personnel frequently perform high-intensity tasks under protective equipment, where elevated metabolic heat production and restricted evaporative cooling accelerate thermal and cardiovascular strain. Conventional heat acclimation protocols often rely on fixed external workloads or environmental chambers, limiting field applicability and failing to individualize heat strain. Prescribing exercise intensity based on relative heart rate (%HRmax) while wearing protective equipment may provide a practical method to standardize heat strain and optimize adaptation in realistic operational conditions.

METHODS
Ten healthy adults will complete a 10-session heat acclimation protocol consisting of a 1-hour treadmill walk at 80%HRmax, wearing protective equipment. Pre- and post-intervention assessments include a standardized high-intensity operational simulation under protective equipment in a climatic chamber (30°C;50%RH). Primary outcomes are final rectal temperature and tolerance time. Secondary outcomes include cardiovascular responses, perceptual strain, isometric strength and cognitive performance. Pre-to-post changes will be analyzed using paired t-tests (or Wilcoxon signed-rank tests when normality assumptions are not met).

RESULTS
Data collection is ongoing, with four of the ten planned participants enrolled to date (one woman; age: 24±3 years, peak oxygen consumption: 51.4±1.2 $mL \cdot kg^{-1} \cdot min^{-1}$; body mass: 70.6±10.1 kg; body mass index: 22±2 kg/m2; waist circumference: 76±6 cm). Data collection and statistical analysis will be completed by late May 2026, and updated results will be presented.

CONCLUSION
This study examines whether heart rate-prescribed exercise performed under protective equipment can induce meaningful thermophysiological adaptation and increase performance in a hot environment while remaining operationally accessible.

MILITARY IMPACT
A chamber-independent heat acclimation strategy that standardizes heat strain under protective equipment may enhance soldiers' ability to sustain repeated high-intensity tasks in hot environments. Such an approach could (1) improve operational readiness, (2) reduce heat-related performance degradation and (3) enhance tolerance to sustained heat exposure during missions.

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Thematic 10 : Thermoregulation in hot environments

#46809054
Oral Presentation

Influence of moisture dynamics on microclimate temperature in protective clothing

BACKGROUND

Despite international conventions prohibiting the use of unconventional weapons, recent conflicts have shown that such threats remain relevant. To mitigate these risks, military personnel wear personal protective equipment that severely restricts heat and moisture exchanges between the body and the environment. This impermeability induces thermophysiological discomfort and increases the risk of heat strain, particularly in hot and humid conditions. In the context of global warming, understanding clothing microclimate behavior has become essential.

METHODS

Experiments were conducted in a controlled climate chamber (30°C, 75 % RH, air velocity 2 m/s). Six participants (4 men, 2 women) performed treadmill walking at 4 km/h with a 1 % incline for 90 minutes, while wearing underwear, socks, shoes, a cotton T-shirt, and a protective suit. Temperature and relative humidity were measured at the back, inside and outside each clothing layer using MSR® sensors (MSR147WD, ±0.1 °C, ±2 % RH). Data were averaged across participants.

RESULTS

Relative humidity within the cotton T-shirt microclimate increased rapidly from 55 % to 90 % during the first 60 minutes, exceeding ambient humidity after 20-30 minutes. Inside the protective suit, humidity increased more gradually, reaching about 85 %, while external measurements remained close to ambient conditions. The microclimate humidity within the protective suit exceeds ambient humidity after approximately 40 minutes. Temperature in both layers exhibited an initial rise followed by a gradual decrease, with earlier and higher peaks observed in the inner layer. These trends reveal a strong coupling between humidity and temperature. Condensation occurring under initially drier clothing conditions led to exothermic heat release, whereas subsequent outward moisture transfer and evaporation resulted in endothermic cooling.

CONCLUSION

Clothing microclimate temperature is strongly governed by moisture dynamics through exothermic and endothermic phenomena associated with water phase changes occurring between the environment and the garments. Understanding these interactions enables a more accurate integration of humidity effects in the design of protective clothing, particularly through material selection, to improve the design of thermophysiological comfort, reduce risks for users, and extend safe wearing time under hot and humid conditions.

MILITARY IMPACT

By improving the understanding of thermal and moisture behavior of protective clothing, this study supports the development of garments better adapted to prolonged use in hot operational conditions, contributing to reduced heat strain and improved soldier safety and operational endurance.

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Thematic 10 : Thermoregulation in hot environments

#47167058
Oral Presentation

Kidney Under Load : Strain or Sustain ?

BACKGROUND
High intensity conflict, combined to global warming, raises the issue of enduring physical intense activity in the heat. Thermoregulation efficiency needs maintaining cardiovascular stability without interrupting activity required for mission. Local blood flow requirements put a stain on cardiac output To maintain cardio circulatory balance. This blood redistribution may induce organ spoliation with a major concern on kidney function. In operational context, this challenge is exacerbated by limited access to water and the use of protective equipment. We hypothesized that prolonged exercise in the heat can lead to acute kidney injury (AKI) in healthy trained human. The first aim was to determine AKI prevalence during a 6-hour race in the heat. Secondary objectives were to identify independent factors of variability and new follow-up biomarkers for renal function after the race.

METHODS
Ten well-trained athletes, 5 females and 5 males, ran the maximum distance over 6 hours, in summer, with regular hydration and feeding. Renal function was assessed based on blood and urine tests. Blood and urine samples were performed 24 hours before the race (Baseline, D-1), immediately upon completion of the race (H0) and then 3 hours, 24 hours and 40 hours after the end of the race (H3, H24, H40). AKI was considered if at least one of different AKI scores was validated (AKIN, RIFLE- creat, RIFLE-GFR, RIFLE-mixt and KDIGO). Data were expressed as mean ± SD. Wilcoxon rank test was performed to compare paired data for each dependent variable.

RESULTS
Race occurred at a mean WBGT 27.5 ± 2.27°C which corresponds to ACSM environmental high risks for all athletes. Well-trained athletes (maximal aerobic speed :18.28 ± 2.39 km/h and body mass index : 20.35 ± 1.54 kg/m²) ran 68.9 km in mean, from 58 km minimum to 84 km maximum. We observed acute kidney injury in 60% of runners when considering one of different AKI scores. We found, in blood analysis, H0 elevation of creatin (D-1: 76.9 ± 12.9 µmol/l vs H0 90.9 ± 18.5), NGAL (D-1: 726.7 ± 235.6 ng/ml vs H0: 951.0 ± 383.1 ng/ml) and C-cystatin (D-1: 597.9 ± 132.9 vs H0: 642.2 ± 161.6 ng/ml which level stayed high during the whole experiment. We also observed moderate CPK elevation which maximum was observed at H3 (D-1: 267.7 ± 183.5 vs H3 1304.0 ± 951.9 mg/ml). Urinary exploration showed rebound for creatinine (H40: 10.98 ± 3.1 mg/ml), cystatine C (H24: 266.6 ± 170.9 ng/ml), NGAL (101.4 -50.7 ng/ml) and KIM1 (637.0 ± 160.0 ng/ml) IGFPB7 (324.4 ± 237.8 ng/ml) and TIMP2 (2226.0 ± 415.3 ng/ml).

CONCLUSION
We here confirmed that prolonged exercise may lead to acute kidney injury in this context of heat environment. Despite slight increase in CPK and optimal conditions for hydration, we found AKI score elevation. New urinary biomarkers may represent a non-invasive pertinent alternative for remote assessment of renal function.

MILITARY IMPACT
Urinary biomarkers may represent a readily available and practical tool for medical follow-up in extreme environments and could assist in clinical decision-making for return to duty and operational preparation optimization.

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Thematic 10 : Thermoregulation in hot environments

#1000052
Poster Presentation

Cognitive-motor dual-tasking under heat stress: performance, perceptual and neuromuscular fatigue responses in athletes

BACKGROUND
Heat stress impairs both physical and cognitive function, yet its impact on simultaneous cognitive-motor dual-tasking (CMDT) remains unclear.

METHODS
Sixteen trained athletes completed two high-intensity CMDT sessions in hot (HOT, 40°C) or temperate (CON, 20°C) conditions. Each 21-min cycling exercise comprised 7-min at a self-paced “strong” intensity followed by 14 min at a fixed-power, based on the last power selected, during which participants performed two 7-min blocks of a sustained attention task (SART). Heart rate (%HRmax), rectal temperature (Trec), and perceived mental effort were monitored, while knee-extensor neuromuscular fatigue was assessed after exercise via femoral nerve stimulation during a 1-min sustained maximal contraction. Data were analysed using repeated-measures analysis of variance and are presented with 95% confidence intervals (CI), and effect sizes (Cohen’s d).

RESULTS
Self-paced power output was lower in HOT (198±49 W) than CON by 25±10 W (95%CI [-35, -13]; d=1.3; P<0.001). %HRmax rose more steeply in HOT (interaction P<0.001), whereas Trec did not differ between conditions (38.5±0.4°C at the end of CMDT exercise; P=0.58). SART performance declined over time by 10±6.7% (95%CI [-9.5, -2.1]; d=0.53; P=0.004), but was consistently lower in HOT than CON by 11±4.2% (95%CI [-15, -6.7]; d=0.99; P<0.001), despite similar increases in perceived effort. The force loss during sustained contraction was greater in HOT (-71±21%) versus CON (-54±19%; d=0.67; P=0.024).

CONCLUSION
Despite lower self-paced power, heat stress further impaired concurrent cognitive performance during CMDT and subsequent force production, indicating greater fatigue development.

MILITARY IMPACT
Heat stress poses a critical threat to mission safety by significantly impairing cognitive accuracy and situational awareness during complex tasks. Notably, physical self-pacing alone appears insufficient to mitigate this decline, highlighting the need for targeted physical and cognitive preparation strategies to prevent potentially critical alterations in performance

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Thematic 10 : Thermoregulation in hot environments

#46777172
Poster Presentation

Thermal strain during arm and leg exercise in multi-layer fully encapsulated whole-body protective clothing

BACKGROUND
A multi-layer fully encapsulated protective clothing restricts evaporative heat loss and limits air exchange. Conventional protective clothing research has emphasized ventilation enhancement, work–rest cycles, or doffing strategies to reduce thermal strain. However, such approaches are not feasible in sealed systems such as space suits or CBRN ensembles used in military operations. Whether localized upper-body activity produces proportionally lower systemic thermal strain compared with leg exercise under encapsulated conditions remains unclear.

METHODS
Eight young males completed three experimental conditions in a randomized crossover design while wearing a multi-layer fully encapsulated protective ensemble in a climate-controlled chamber (22 ± 2°C, 53 ± 5% RH). Each condition lasted 60 min: (1) seated rest (CON), (2) Rest–Arm exercise–Break–Arm exercise (ARM), and (3) Rest–Walking on a treadmill–Break–Walking on a treadmill (LEG). Rectal and gastrointestinal temperature, auditory canal temperature, 12-site skin temperature, heart rate, metabolic rate, and, clothing microclimate were recorded continuously. Repeated-measures analysis of variance with Bonferroni correction was applied ($P < 0.05$).

RESULTS
Core temperature was significantly greater in both LEG and ARM than in CON ($P < 0.05$). Auditory canal temperature, skin temperatures (except chest temperature), clothing microclimate variables, and total sweat rate showed no significant differences between LEG and ARM ($P > 0.05$). However, chest skin temperature was significantly higher in ARM than in LEG following the first exercise bout (ARM: 36.9 ± 0.5oC > LEG: 36.0 ± 0.6oC; $P < 0.05$). Heart rate was higher in ARM than in LEG during the first exercise bout (ARM: 158 ± 19 bpm > LEG: 134 ± 11 bpm; $P < 0.05$), but values converged to similar levels by the second bout. In contrast, metabolic rate was significantly higher in LEG than in ARM ($P<0.01$). Clothing microclimate humidity reached around 99%RH during the 2nd exercise at the chest, upper back, and thigh with no differences between ARM and LEG, while below 70%RH was found for CON.

CONCLUSION
Under fully encapsulated conditions, arm exercise induces systemic thermal burden comparable to leg exercise on a treadmill. Microclimate humidity accumulation substantially limits evaporative heat dissipation and contributes to progressive heat storage.

MILITARY IMPACT
Military personnel operating in sealed CBRN or space-related protective systems frequently perform upper-body–dominant tasks. These findings demonstrate that even localized arm activity can produce systemic heat strain comparable to locomotion, potentially increasing heat casualty risk during high-intensity missions. Thermal mitigation strategies targeting both core temperature control and internal humidity reduction are essential to enhance operational endurance and mission effectiveness.

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Thematic 10 : Thermoregulation in hot environments

#46787813
Poster Presentation

Morphological and biological characteristics of heat intolerant individuals in a military cohort

BACKGROUND
Following exertional heat stroke, heat tolerance (HT) testing is commonly used during the return-to-duty process in military personnel. The anthropometric and aerobic characteristics associated with heat intolerance (HI) are well documented, including higher body mass, increased body fat percentage, and lower aerobic capacity. However, the basal biological profile of HI individuals remains poorly characterized. A comprehensive understanding of interindividual vulnerabilities to heat stress may require the integration of relevant biomarkers in order to complete the phenotypic profile of HI.

METHODS
A cohort of 56 soldiers (5 females) performed a heat tolerance test (HTT). HI was declared if core temperature exceeded 38.5°C after two hours of treadmill walk at 5 km/h in a chamber set to 40°C and 40% of relative humidity. Maximal oxygen uptake (VO2max) was estimated using a submaximal cycling test and anthropometric measurements were obtained the day before the HTT. Rectal temperature was continuously monitored during the HTT. Venous blood samples were collected immediately before the HTT. Analyses included metabolic, hormonal and inflammatory markers in blood (glycaemia, insulin, IL-1Ra and IL-6). Between-group differences were assessed using independent t-tests.

RESULTS
45% of the whole cohort were HI showing a mean final rectal temperature of 39.0°C ± 0.38°C, whereas 55% were HT with a mean of 38.0 ± 0.27°C. Compared to HT, HI had higher body weight ($p<0.05$, 82.4 ± 10.4 vs. 75.5 ± 11.1kg) and fat percentage ($p<0.001$, 25.92 ± 5.58 vs. 19.16 ± 5.49%), lower body surface area-to-mass ratio ($p=0.001$, 239 ± 19 vs. 254 ± 15cm²/kg) and VO2max ($p<0.001$, 43.2 ± 5.8 vs. 49.7 ± 6.1mL/min/kg). Regarding biological markers, baseline concentrations in glycemia ($p=0.052$, 5.2 ± 0.45 vs. 4.9 ± 0.5mmol/L), insulin ($p<0.05$, 2.28 ± 0.35 vs. 2.04 ± 0.40 pg/mL), plasmatic IL-6 ($p<0.05$, 1.01 ± 0.33 vs. 0.86 ± 0.17 log10(pg/mL)) and IL-1Ra ($p<0.001$, 2.33 ± 0.17 vs. 2.16 ± 0.16 log10(pg/mL)) were respectively higher in HI compared to HT participants.

CONCLUSION
In addition to the typical features associated with HI (higher body weight and fat percentage, and lower aerobic capacity), HI participants exhibited higher baseline glucose and insulin levels and inflammatory markers than HT participants. This specific profile suggests a pre-existing state of metabolic stress with lower insulin sensitivity with a low-grade of inflammation in these individuals.

MILITARY IMPACT
These results support the need to implement adequate physical training programs, and appropriate dietary strategies to promote physical fitness, metabolic health and HT.

AUTHORS

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Thematic 10 : Thermoregulation in hot environments

Poster Presentation

Predicting performance degradation in United Kingdom CBRN PPE: optimising capacity to train safely and operate effectively

BACKGROUND

United Kingdom (UK) counter-chemical, biological, radiological and nuclear (CBRN) personnel operate in protective dress state 4, where heat stress and exertional heat illness (EHI) can degrade performance and threaten safety. Current UK CBRN and wet bulb globe temperature (WBGT) work-rest tables are derived from thermal manikin data and may not fully reflect human physiological or central nervous system (CNS) responses during specialist military tasks. This project aims to validate existing work-rest guidance and explore whether early changes in CNS performance can support personalised prediction of EHI risk.

METHODS

This three-year applied physiology-neuroscience programme will study specialist counter-CBRN work across three linked work packages. First, wearable sensors will quantify heat strain during routine warm- and cold-weather training, including measures of skin temperature, humidity, core temperature, electrocardiography, movement and activity. These data will be used to calibrate current work-rest tables and develop a representative laboratory model of counter-CBRN work. Second, a functionally relevant cognitive-motor task will be developed and validated, with task performance, markerless motion capture, functional near-infrared spectroscopy and neuromuscular fatigue assessment used to characterise performance degradation. Third, simulated counter-CBRN work will be conducted in an environmental chamber under warm and cool conditions matched to field wet bulb globe temperature recordings. Participants will exercise beyond current table limits until institutional safety thresholds are reached, allowing identification of the time point at which CNS performance first declines.

RESULTS

This is a prospective study; final outcome data are not yet available. Expected outputs include human physiological calibration data for UK CBRN WBGT work-rest tables, a validated laboratory model of specialist counter-CBRN work, and proof-of-concept evidence for detecting CNS decompensation and EHI risk from wearable and task-performance data.

CONCLUSION

By linking field physiology, laboratory validation and environmental chamber simulation, this project will determine whether subtle CNS impairment precedes overt EHI during chemical, biological, radiological and nuclear protective equipment use. The findings may support more precise, human-data-informed work-rest guidance and early-warning approaches for heat-related performance degradation.

MILITARY IMPACT

In high-intensity conflict, counter-CBRN personnel must maintain operational effectiveness while wearing PPE in thermally challenging environments. Improved prediction of performance degradation and EHI risk could optimise safe training capacity, extend effective operational endurance and inform personalised decision-support tools for Commanders and medical teams.

AUTHORS

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Thematic 11 : Heat, Thermal Strain, and Physiological Monitoring : From sensing to prediction and real-time risk mitigation in operational environments

Salle Moebius - Mod: K. Friedl + M. Quiquempoix + A. Sedeaud

ORAL PRESENTATIONS

Progression of Step-to-Step Variability During a Military March Using Upper Arm Acceleration

Impedance Cardiography for Monitoring Individual Physiological Strain during Loaded Military Marching: Comparison with Spiroergometric Measures

User-centred Development of an Arm-based Real-Time Physiological Strain Monitoring and Alert System for Soldiers Training in the Heat

Comparative Analysis of Absolute and Individually Developed Physical Activity Metrics Derived from Non-Dominant Wrist Accelerometry in Combat Service Support Personnel

Validity of Wearable Heat Stress Monitors During Operational Training in a Hot Environment

POSTER PRESENTATIONS

Heart rate monitoring of elite combat soldiers during Iron Sword subterranean operations

Monitoring Facial Muscle Electrical Activity as a Quantitative Indicator of Effort Intensity and Fatigue during Grip Tasks: A Single-Subject Pilot Study for Human-Machine Teaming

Through the Ringer: Stress Testing Oura Ring 4 Sleep-Tracking Performance in Multiple Operational U.S. Navy Contexts

From Risk to Readiness: Scalable Wearable Heat-Strain Monitoring for Military Training

Designing and Validating a Modular Ecosystem for Real-Time Physiological Monitoring and Performance Optimization in High-Risk Operations

Project „VitalMonitor“: Real-Time Physiological Status Monitoring in the Austrian Armed Forces – an Overview

Building Analysis-Ready Multimodal Datasets Integrating Physiological Sensors, Salivary Biomarkers, and Pre/Post Assessments in Military Selection

Biological sample processing in a temporary field laboratory: operational experience from the PENTHERE study

Improving the accuracy of energy expenditure estimates by utilizing a heat flux sensor in wearable devices

Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46371672
Oral Presentation

Progression of Step-to-Step Variability During a Military March Using Upper Arm Acceleration

BACKGROUND
Prolonged military marching with load carriage exposes soldiers to a high risk of musculoskeletal injury and exertional heat illness. Continuous, field-based monitoring approaches are therefore needed to detect accumulating biomechanical strain during long duration tasks. Gait variability reflects step-to-step changes in locomotor control and may serve as a noninvasive indicator of progressive fatigue and altered movement strategies. However, little is known about how gait variability evolves during extended, real-world military marches using upper arm sensors suitable for operational monitoring.

METHODS
This observational field study examined short-term gait variability during a self-paced 90 km (2.4 km ascent, 3.0 km descent) loaded military march conducted in November as part of a Swiss military cadet school and was approved by the cantonal ethics committee of Bern, Switzerland. Triaxial acceleration was continuously recorded from the upper arm using a wearable inertial sensor. Gait variability was quantified as one minus the step-to-step Pearson autocorrelation of consecutive steps derived from the acceleration magnitude. March data were segmented into five consecutive 18 km sections, and median gait variability was calculated per participant and segment. Differences across march segments were assessed using repeated measures analysis of variance with Greenhouse-Geisser correction and Holm-adjusted post hoc comparisons.

RESULTS
Nineteen cadets (age = 21.4 ± 1.6 years, height = 179.2 ± 10.0 cm, weight = 79.1 ± 9.1 kg) contributed complete data across all analyzed march segments. Average walking time was 21 h and 4 min ± 1 h 10 min. Gait variability increased progressively with march progression, from 0.086 ± 0.030 in the first segment (0-18 km) to 0.190 ± 0.073 in the final segment (72-90 km), accompanied by increasing interindividual dispersion. A significant effect of march segment on gait variability was observed ($p < 0.001$). No difference was detected between the first two segments, whereas all subsequent segment comparisons were statistically significant ($p \leq 0.018$), with six of ten pairwise segment comparisons resulting in effect sizes of $|d| = 0.8$ or above.

CONCLUSION
Short-term gait variability increased systematically during prolonged loaded marching, indicating progressive alterations in locomotor regularity as physical strain accumulated. These findings demonstrate the feasibility of using simple, arm-worn wearable sensors to capture meaningful gait adaptations under real-world military conditions.

MILITARY IMPACT
Gait variability using upper-arm acceleration may represent a valuable biomechanical marker to support continuous soldier monitoring and early identification of elevated injury or heat-related risk during prolonged military operations.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46709286
Oral Presentation

Impedance Cardiography for Monitoring Individual Physiological Strain during Loaded Military Marching: Comparison with Spiroergometric Measures

BACKGROUND

Monitoring physiological strain during military-specific physical tasks is of increasing interest for soldiers' performance optimization, injury prevention and enabling immediate medical assessment and treatment in the event of injury. While spiroergometry is considered the gold standard for assessing aerobic demands, its applicability in field settings is limited. Impedance cardiography (ICG) offers a non-invasive and potentially field-deployable alternative for continuous cardiovascular monitoring. To our knowledge, this is the first study to use ICG for monitoring military-specific load under realistic conditions with full ballistic protective equipment and high external load (~32 kg). The purpose of this analysis was to evaluate the capability of ICG to track individual exercise load during a military marching task and to examine the physiological plausibility of ICG-derived cardiac output compared with spiroergometric measures.

METHODS

Twenty-one healthy male voluntary soldiers completed a standardized 6 km loaded marching protocol in a repeated-measures design on separate days with two marching speeds (4.5 $km \cdot h^{-1}$ and 6.0 $km \cdot h^{-1}$). Marching was divided into 4 sections of 1.5 km (Q1-Q4). This was followed by 5 running intervals (15 s, 13 $km \cdot h^{-1}$) and an all-out running test (13 $km \cdot h^{-1}$ until exhaustion) with 2 min pauses between marching, intervals and maximum effort test. All soldiers were uniformly dressed and wore a ballistic protective vest with additional weight corresponding to a full combat load (total load: 32 kg). Exercise testing was performed with simultaneous spiroergometric assessment (relative oxygen uptake, rVO_2) and impedance cardiography (cardiac index, CI). To assess the ability of both methods to track intra-individual changes, z-scores were calculated and individual temporal profiles plotted. Physiological plausibility was evaluated by computing within-subject Pearson correlations between zCI and $zrVO_2$ and by analyzing z-score differences (Δ = zCI − $zrVO_2$) per load stage using mean, standard deviation and standard error.

RESULTS

Both spiroergometry and ICG recorded intra-individual changes in physiological strain during the marching task. Mean within-subject Pearson correlation between zCI and $zrVO_2$ was 0.90 (SD = 0.07). Z-score differences averaged near zero across all load stages, confirming overall agreement between methods. During intermediate pauses, Δ (zCI − $zrVO_2$) was positive (~0.45), whereas during marching stages, Δ was slightly negative (~−0.19). The temporal course of ICG-derived cardiac output was comparable to that of rVO_2 across load stages.

CONCLUSION

Impedance cardiography showed a high within-subject association with spiroergometric VO_2 and comparable temporal responses across exercise stages. These findings support its use as a feasible non-invasive method for monitoring exercise load during military-specific physical tasks.

MILITARY IMPACT

Under realistic operational conditions with ballistic protective equipment and high external loads, ICG allows continuous assessment of individual cardiovascular strain while potentially causing less impact on vision, perceived exertion and movement compared with spiroergometry. These ICG capabilities might support field-based performance monitoring and operational decision-making.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46710545
Oral Presentation

User-centred Development of an Arm-based Real-Time Physiological Strain Monitoring and Alert System for Soldiers Training in the Heat

BACKGROUND
Exertional heat stroke (EHS) remains a persistent risk during moderate-to-high intensity military training and operations in warm-humid environments. Remote monitoring capabilities can provide commanders, trainers and medics with real-time, objective indicators of individual physiological strain (e.g., cardiovascular and thermal strain) to support timely, evidence-informed risk-mitigation decisions. We aimed to down-select a fit-for-purpose arm-based wearable and develop a real-time body core temperature (Tc) estimation and heat-strain alert capability to enable a pathway for practical and scalable remote physiological strain monitoring (PSM) of soldiers training in the heat.

METHODS
Using a four-phase, user-centred co-design pipeline, we: (i) conducted a landscape review of commercially available wearables and screened them against operational requirements and raw-signal access; (ii) translated end-user needs and risk tolerance into a structured evaluation,down-selection and deployment prioritisation framework; (iii) conducted laboratory and field benchmarking of shortlisted devices for signal quality, measurement performance, acceptability and deployability; then (iv) collected paired field data with reference Tc to develop an arm-based Tc estimation model with optimised alert thresholds, and benchmarked its performance against the down-selected wearable's existing on-board Tc estimation model (ECTemp).

RESULTS
From 212 devices screened, four were shortlisted (Polar Verity Sense, Equivital eq LifeBand, Samsung Galaxy Watch 6, Mobvoi TicWatch Pro 5). Across laboratory (n=33) and field (n=13) trials, the eq LifeBand best balanced signal fidelity, measurement performance and deployability and was down-selected for model development. Using 388 paired datasets across 20 field trials involving eight different military activities), an arm-based Tc estimation model [overall: mean absolute error (MAE)=0.28 °C, mean based error (MBE)=0.07 °C; Tc≥39.5 °C: MAE=0.43 °C, MBE=-0.43 °C] and optimised alert thresholds achieving sensitivity=94% and specificity=82% for Tc≥39.5 °C was developed. Compared with the wearable's on-board ECTemp estimate, the arm-based model demonstrated reduced error (MAE: 0.28 °C vs 0.42 °C overall; 0.43 °C vs 0.87 °C for true Tc≥39.5 °C) and markedly improved sensitivity for Tc≥39.5 °C (94% vs 2%).

CONCLUSION
A user-centred, evidence-based translational pipeline aligned device selection with operational constraints and stakeholder priorities, accelerating progress towards a practical, scalable monitoring capability. Further, the down-selected device enabled the development of an arm-based Tc estimation model with operationally relevant accuracy and high sensitivity for Tc ≥ 39.5°C, outperforming the wearable's existing on-board ECTemp estimate and supporting its future integration into a real-time PSM and alert capability for military training in the heat.

MILITARY IMPACT
This study delivers an evidence-based, operationally co-developed pathway to scalable, real-time monitoring and early warning of elevated physiological strain. It balances fit-for-purpose deployment with scientific rigour to support earlier intervention for safer training and operations in hot-humid environments.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46733506
Oral Presentation

Comparative Analysis of Absolute and Individually Developed Physical Activity Metrics Derived from Non-Dominant Wrist Accelerometry in Combat Service Support Personnel

BACKGROUND
Wrist-worn accelerometers are widely used to quantify physical activity intensity and training load in military monitoring systems. These devices usually use fixed absolute cut points derived from general populations. During high-intensity exercise, such thresholds may not accurately reflect relative physiological effort and may misclassify maximal performance. This study examined whether individualized calibration based on a standardized maximal running test improves agreement between wrist-derived intensity classification and physiological intensity.

METHODS
Seventy-four Belgian military office workers (43 men, 31 women; mean age 39.3 ± 9.3 years) completed a maximal 2400 m running test while wearing a non-dominant wrist accelerometer (ActiGraph GT9X) and a chest-worn physiological monitor (Zephyr BioHarness). Peak heart rate during the test served as the physiological reference for relative intensity. Wrist-based absolute cut-points were compared with individualized cut-points calibrated to each participant's physiological capacity, derived from the mean of the three highest consecutive one-minute acceleration epochs during the test. Agreement between accelerometer-based and heart rate–based intensity classification was evaluated using Cohen's kappa, intraclass correlation coefficients, and receiver operating characteristic analyses with 95% confidence intervals. Statistical significance was set at $p < 0.05$.

RESULTS
Participants achieved near-maximal physiological effort (peak heart rate 187 ± 11 bpm; 95 ± 4% of age-predicted maximum). Despite this confirmed maximal effort, only 34.5% of participants were classified as predominantly vigorous using absolute thresholds. Individualized calibration substantially improved classification accuracy. Agreement with heart rate increased from $\kappa = 0.31$ to $\kappa = 0.74$ ($p < 0.001$). Intraclass correlation improved from 0.52 (95% CI: 0.35–0.66) to 0.81 (95% CI: 0.73–0.87). Discriminatory performance improved from AUC 0.68 (95% CI: 0.58–0.78) to AUC 0.89 (95% CI: 0.82–0.96).

CONCLUSION
Absolute wrist-worn accelerometer cut points significantly underestimated the intensity of maximal running in non-combat military personnel. By using individualized calibration based on a standardized maximal field test, a much better alignment with physiological intensity and significantly reduced misclassification at the higher end of the intensity range was achieved.

MILITARY IMPACT
Accurately capturing high intensity physical effort is essential in fast paced operational settings, where it's important to track training load, recovery, and overall readiness with precision. Relying on fixed, generic thresholds can downplay the true level of activity and overlook how much individuals differ in their physiological responses. By integrating individualized calibration into regular fitness assessments, wearable monitoring becomes more reliable and can better support informed decisions about readiness and workload management.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#47132301
Oral Presentation

Validity of Wearable Heat Stress Monitors During Operational Training in a Hot Environment

BACKGROUND
Military personnel operating in urban environments may be exposed to substantial radiant heat and exertional heat strain whilst operating in or near burning structures or vehicles. These conditions can elevate physiological strain and increase the risk of heat-related illness. This study was conducted to assess the validity of two wearable heat stress monitors (HSM) for estimating core body temperature during training scenarios involving extreme radiant heat exposure.

METHODS
Thirty-one healthy volunteers (29 male, 2 female; age 41 ± 10 years, height 177 ± 7 cm, body mass 87 ± 14 kg, body mass index 27.6 ± 3.4 $kg \cdot m^{-2}$, estimated body fat 22.2 ± 5.4 %) completed two operational training scenarios in a metal shipping container involving extreme radiant heat exposure from a fire while wearing full personal protective equipment. Scenarios included a static (physically inactive) exposure (SE) and dynamic (equipment drag task) exposure (DE) lasting an average of 32 ± 5 and 38 ± 14 mins respectively. Gastrointestinal temperature (Tgi) (the criterion measure) was measured continuously alongside two wearable HSM (Equivital chest sensor and CORE arm sensor) to estimate core temperature (Tc). Validity was assessed using bias, 95 % limits of agreement (LoA), mean absolute error (MAE), root mean square error (RMSE), Pearson's r, Lin's concordance correlation coefficient (CCC), and the proportion of readings within ± 0.3 °C of Tgi. The study was approved by the University of Bath Research Ethics Approval Committee (ref: 6265-7509).

RESULTS
Mean Tgi increased during the exposures from 37.2–38.1 °C, with individual peak values reaching 39.5 °C. Whilst CCC was better for Equivital compared to CORE during both exposures, correlation coefficients ranged from 0.29–0.60, indicating poor concordance across both devices in both exposures. Bias was minimal for Equivital (0.02–0.05 °C), whereas CORE demonstrated a consistent negative bias relative to Tgi (−0.26 to −0.29 °C). Limits of agreement were broadly similar between devices ranging from 1.43–1.73 °C for Equivital and 1.49–1.58 °C for CORE. RMSE values were lower for Equivital (0.30–0.36 °C) than CORE (0.41–0.43 °C). The proportion of device readings within ± 0.3 °C of Tgi varied between devices and simulations, ranging from 41–62 %, with Equivital demonstrating a higher proportion of readings within this threshold than CORE during both SE and DE. However, substantial inter-individual variability was observed, reflected by wide participant ranges (0–100 %) across all devices and scenarios.

CONCLUSION
Whilst Equivital performed better than CORE, both devices demonstrated poor agreement with Tgi and substantial individual variability during static and dynamic environments involving extreme radiant heat exposure.

MILITARY IMPACT
These findings suggest that current wearable heat stress monitors should be used cautiously for individual heat strain monitoring in extreme environments with or without exertional heat strain.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46505644
Poster Presentation

Heart rate monitoring of elite combat soldiers during Iron Sword subterranean operations

BACKGROUND
Real-time heart rate (HR) monitoring in subterranean combat environments provides critical insights into soldiers' physiological responses to the combined physical, environmental, and psychological demands of underground operations. Wearable technologies such as Garmin watches enable systematic assessment of HR dynamics to quantify physiological strain, inform training strategies, and optimize recovery protocols. These data-driven metrics support evidence-based decision-making to enhance operational readiness, performance resilience, and personnel survivability in subterranean settings. Objectives: (1) to evaluate the importance of real-time physiological monitoring in elite combat soldiers during subterranean operational contexts; (2) to examine the relationship between HR dynamics, ventilatory thresholds (predicted aerobic and anaerobic transitions), and age-predicted maximal HR as indicators of physiological strain; (3) to identify the operational utility of physiological insights for enhancing soldier readiness, recovery time, and mission effectiveness.

METHODS
Continuous HR monitoring was performed using Garmin wearables during subterranean operations of 7 elite combat soldiers. HR zones corresponding to estimated ventilatory thresholds (VT1, VT2) and maximal HR were calculated. HR recovery, HR variability (HRV), and stress index were also assessed (arbitrary units). Mean and standard deviation were calculated.

RESULTS
Analysis encompassed 12 hours of subterranean monitoring data from elite combat soldiers. Mean HR was 143 $b \cdot min^{-1}$ (range: 80–196 $b \cdot min^{-1}$), with time spent in aerobic (zone 2): 74.6%, transition (zone 3): 10.8%, anaerobic (zone 4): 4.3%, and maximal (zone 5): 0.7%. Mean stress index was 150.0 ± 22.7, training load 286.1 ± 30.8, recovery quality 71.9 ± 9.1, and HRV score 70.4 ± 8.8.

CONCLUSION
Real-time HR monitoring during subterranean combat operations provides quantifiable physiological metrics to support commander and medical personnel decision-making, enhancing soldier safety, resilience, and operational performance.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46738825
Poster Presentation

Monitoring Facial Muscle Electrical Activity as a Quantitative Indicator of Effort Intensity and Fatigue during Grip Tasks: A Single-Subject Pilot Study for Human-Machine Teaming

BACKGROUND
Facial expression quantification through surface electromyography (sEMG) has significant potential for fatigue evaluation. However, convenient and accurate measurement during physical tasks remains a technological challenge. This study utilizes a novel, flexible multi-array electrode sensor to investigate whether facial sEMG can serve as an independent physiological indicator of effort intensity and physical fatigue for future Human-Machine Teaming (HMT).

METHODS
A single healthy female subject performed a controlled grip protocol while facial sEMG was continuously recorded using a 16-electrode array covering the forehead, zygomatic, and labial regions. Forearm Flexor Digitorum Superficialis (FDS) sEMG and a digital dynamometer provided reference metrics. The protocol consisted of: (1) Maximum Voluntary Contraction (MVC) assessment; (2) a graded force task (20%–100% MVC); (3) a 60% MVC sustained force modulation task; and (4) a repeated MVC fatigue assessment (10 repetitions). Data was filtered to calculate Root Mean Square (RMS) and median frequency (MF).

RESULTS
During graded tasks, facial RMS showed an increasing trend correlated with FDS activity and target force. Analysis of novel grip parameters revealed that grip instability (Delta parameter) directly correlated with increased facial RMS. Conversely, the Area Under the Curve (AUC) dropped significantly during 100% MVC efforts as the subject struggled to maintain force within the $\pm$20% target range. System stability was confirmed during sustained efforts, with only negligible momentary anomalies (~0.01–0.02 mV). In the repeated MVC fatigue test, a classic peripheral fatigue marker was evident as FDS median frequency declined from 117 Hz to a range of 84–96 Hz. Under this extreme fatigue, a divergence emerged: facial sEMG trends remained distinct while grip force declined, suggesting that facial activity reflects exerted effort even when peripheral muscular capacity is diminished.

CONCLUSION
This proof-of-concept demonstrates that facial sEMG yields quantitative insights into functional performance and effort. The correlation between facial activity and grip instability suggests that continuous monitoring could provide an "objective window" into an operator's state. These preliminary findings establish a foundation for multi-subject studies to validate facial sEMG as a metric for "Human State Aware Systems" in operational environments.

MILITARY IMPACT
Identifying operators' physical and cognitive fatigue before functional failure is critical for future battlefield Human-Machine Teaming, such as remote operators and vehicle crews. Utilizing high-resolution facial sEMG as an objective window into physical capacity paves the way for "Human State Aware Systems" capable of dynamically adjusting to operator overload in real-time, thereby maintaining situational awareness and preventing critical operational errors.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46748193
Poster Presentation

Through the Ringer: Stress Testing Oura Ring 4 Sleep-Tracking Performance in Multiple Operational U.S. Navy Contexts

BACKGROUND
Consumer wearable health technology continues to rapidly advance and is now being used more frequently in operational contexts for monitoring service member readiness. For instance, capabilities that aggregate sleep data at the group level may help inform processes and decisions to mitigate fatigue. Despite this, nearly all wearable validation studies have been conducted in general populations and controlled settings, limiting their applicability to operational contexts (e.g., irregular sleep patterns, disruptive sleep environments). The current study evaluated the sleep-tracking performance of the newest Oura Ring model against electroencephalography (EEG) in multiple U.S. Navy operational contexts.

METHODS
Participants were active duty U.S. Navy Sailors from multiple operational studies: shipboard sleep from one command in port (n = 49) and shore-based sleep from two commands working rotating shifts (n = 9). Sailors wore two devices during sleep: Oura Ring 4 (Oura Health Oy) and Somfit EEG forehead patch (Compumedics Ltd.). Sleep data from both wearables were provided from their proprietary sleep-staging algorithms. Performance was assessed with sleep summary and 30-second epoch-level comparisons.

RESULTS
The final analytical sample included 298 sleep periods. Mean bias and limits of agreement for Oura sleep summary outcomes were total sleep time (2.0 ± 44.4 min), sleep efficiency (1.0 ± 15.2%), sleep onset latency (1.9 ± 20.2 min), wake after sleep onset (-3.4 ± 41.2 min), light sleep (11.4 ± 64.4 min), deep sleep (-0.2 ± 66.6 min), rapid eye movement (REM) sleep (-9.2 ± 47.6 min). Epoch-level sensitivity and specificity, respectively, were all sleep (0.94, 0.48), light sleep (0.75, 0.72), deep sleep (0.66, 0.92), and REM sleep (0.71, 0.95).

CONCLUSION
Overall, the Oura Ring 4 performed as well in military contexts as prior Oura models did in laboratory and general-population studies. Sleep summary outcomes showed relatively small biases that are typically deemed acceptable for wearables. The epoch-level sensitivity and specificity trade-offs follow similar patterns to those in prior studies and offer valuable insights into what conclusions can be drawn from wearables in large datasets. Though the current study addressed shipboard sleep and shift workers, future studies evaluating wearables in additional military contexts will be critical to understanding their strengths and limitations in fatigue risk management efforts.

MILITARY IMPACT
Wearable technology is rapidly advancing and being used more frequently in operational contexts for monitoring service member sleep for individual health tracking and group-level fatigue mitigation efforts. However, wearable validation studies have largely only been conducted in general populations and/or controlled settings. In the current study, we evaluated the sleep-tracking performance of the newest Oura Ring model in multiple U.S. Navy operational contexts and find its overall performance was as good as previous Oura device models, providing initial evidence supporting its continued use for tracking sleep in military contexts

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46782808
Poster Presentation

From Risk to Readiness: Scalable Wearable Heat-Strain Monitoring for Military Training

Heat illness remains a persistent operational risk in military training contexts characterized by high physical exertion and environmental exposure. In 2022 alone, more than 2,300 U.S. Warfighters experienced heat stroke or heat exhaustion, with disproportionate impact among Marines and newly enlisted personnel. Rising temperatures worldwide and decreasing physical fitness levels of recruit trainees make monitoring and preventing heat illness more important than ever. Despite the preventability of exertional heat illness, existing monitoring approaches often face limitations in scalability, usability, and integration into training workflows.

In response, our team developed a wearable heat strain assessment system that can proactively alert individuals and their trainers to high-risk situations while operating on a modern, secure, and scalable technology stack. The goal is to prevent heat strain/heat illness incidents more frequently than currently possible so that early intervention can occur to avoid a life-threatening emergency. For circumstances that are inevitably less preventable (i.e., lacking early indicators or rapidly escalating to emergency status), the system would immediately identify the situation and location of the impacted individual while supplying a record of physiological data leading up to the incident. The heat stress tailored system is built upon two commercially available components developed by VigiLife: the Shield wearable sensor and the SafeGuard software-as-a-service (SaaS) platform. The Shield armband form factor was selected to balance physiological signal fidelity with durability and minimal interference during training tasks. The device collects multimodal data streams, including skin temperature, heart rate, and triaxial accelerometry. These signals support five heat-strain detection algorithms originally developed by U.S. Army Research Institute of Environmental Medicine (USARIEM), enabling both on-device threshold-based alerting and cloud-enabled monitoring through SafeGuard.

These algorithms include estimated core body temperature (EC-Temp), adaptive physiological strain index (aPSI), gait instability index (GInI), exertional heat stress (EHS), and exertional heat illness alerting algorithm (EHIAA).

Furthermore, the system emphasizes human-centered design by providing modularity, configurability, and hierarchical data visibility. Multiple kit configurations support deployment across heterogeneous user populations (e.g., recruits, instructors, medics), allowing adaptation to unit size, mission duration, and environmental severity.

An additional SaaS layer provides role-based dashboards, alert triage workflows, and longitudinal exposure tracking, facilitating integration into existing training command structures without increasing burden.

Edge processing supports low-latency alerts in bandwidth-constrained environments, while synchronized cloud analytics enable retrospective analysis for policy refinement and risk modeling.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46807731
Poster Presentation

Designing and Validating a Modular Ecosystem for Real-Time Physiological Monitoring and Performance Optimization in High-Risk Operations

High-risk operational environments place significant cognitive, physical, and physiological demands on personnel, increasing the likelihood of fatigue, stress, and performance degradation. Despite the growing availability of wearable sensors and real-time monitoring systems, integrating these technologies into existing workflows and translating data into actionable interventions remains challenging, particularly in complex, multi-domain missions.

The MAVERIC ecosystem addresses this gap by providing a modular, end-to-end solution for physiological monitoring, performance modeling, and intervention delivery. The MAVERIC wearable device enables robust wearable sensing via near-infrared spectroscopy (NIRS) and photoplethysmography (PPG), packaged in a slim, rugged form factor. The system provides real-time monitoring capabilities for indicators such as functional brain activation, pulse rate, respiration rate, and pulse oximetry, and delivers tailored interventions to mitigate risk and enhance operator resilience. Together, this suite of tools allows organizations to continuously assess and optimize personnel health and performance, bridging the gap between data acquisition and actionable outcomes while supporting safe, high-stakes operations.

The MAVERIC system is currently undergoing multiple validation studies conducted by both the development team and independent researchers in government laboratories. These efforts include verifying derived analytics such as respiration, testing alert performance under hypoxic conditions, and assessing motion-resistance during ambulatory use.

Preparations are also underway for validation in live flight scenarios, where both instructor and trainee pilots will be outfitted with MAVERIC devices. Demonstrating reliable functionality across these various conditions is essential for establishing the system's potential to enhance operational performance and training outcomes.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46808287
Poster Presentation

Project “VitalMonitor”: Real-Time Physiological Status Monitoring in the Austrian Armed Forces – an Overview

BACKGROUND

Real-Time Physiological Status Monitoring (RT-PSM) is nowadays commonly used in professional sports to optimize training, performance, regeneration and athlete health management. Also, there are multiple approaches for the application of RT-PSM in military settings, to prevent the “tactical athletes” from psychophysiological overload, improve and individualize their training, and strengthen their resilience against various stresses. The aim of the project “VitalMonitor” was to develop a RT-PSM – Demonstrator for specific use cases in the Austrian Armed Forces (AAF).

METHODS

In the 1st phase a “Smart-Shirt”, which collects multiple physiological and motion data, was evaluated regarding the accuracy of all measurements in laboratory settings with young and healthy sports students. Then (2nd phase), the system was applied to soldiers of different branches (CBRN, EOD, Infantry) in military-specific environments, with particular attention to measurement precision and wearing comfort of the shirt in various scenarios, and different environmental and clothing conditions. After that, (3rd phase), VitalMonitor was tested in live-exercises and maneuvers of CBRN and infantry soldiers. Finally (4th phase), 5 critical tasks of the infantry were focused to explore the usability of VitalMonitor, and data from a sample of 241 soldiers (age: 22.6±5yrs, height: 181±7cm, weight: 80.7±10kg, BMI: 24.5±3, bodyfat: 15.8±4%) were collected in a standardized procedure for in-depth analyses and evaluation. Altogether, more than 650 male and female soldiers were tested in various military-specific gears, equipment settings and scenarios, so far. Data analyses were conducted with diverse descriptive and inferential methods, also machine learning approaches were applied.

RESULTS

The sensors of the Smart-Shirt were evaluated, and delivered valid data in laboratory settings, but showed some problems when collecting respiratory rate under field conditions, especially in intense infantry scenarios while wearing heavy gear and moving quickly into different body positions.

In CBRN-scenarios with specific clothing ensembles data transfer from the On-Board-Unit (OBU) to the server was an issue. The usability, especially regarding the wearing comfort, does not apply to all military branches equally. While the shirt did not interfere with CBRN and EOD personnel in their protective clothing, it occasionally caused discomfort for infantry soldiers in high-intensity scenarios. Therefore, several modifications of the shirt were made, e.g.: reducing size, usage of softer materials, enhancements in the embedding of the OBU, and a new node for better data transfer were delivered. Data-based load-strain-models were developed for the 5 critical tasks of the light infantry. Additionally, prediction models for the expected physiological strain in 5/10/15 minutes were generated. Furthermore, an intuitive dashboard was designed for different user-groups and requirements, especially for military commanders and exercise physiologists.

CONCLUSION

The proof of concept is already scheduled with an infantry platoon, to be equipped with VitalMonitor for a trial period of 3 month, to get insights and knowledgement about the usability and accuracy of the system in “real-military-life-settings”.

MILITARY IMPACT

The achievements of this project have potential for medium-term implementation in the AAF, to optimize training and avoid physiological overload of the soldiers.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#46941293
Poster Presentation

Building Analysis-Ready Multimodal Datasets Integrating Physiological Sensors, Salivary Biomarkers, and Pre/Post Assessments in Military Selection

BACKGROUND
Multimodal monitoring in operational environments produces heterogeneous data streams that differ in sampling rate, temporal structure, and missingness mechanisms. This heterogeneity makes direct fusion unreliable and can cause downstream analyses to reflect data gaps and interpolation rather than true physiology. A standardized process is therefore essential to transform raw recordings into quality-controlled, completeness-aware aligned time series that support valid and reproducible modeling. We present a structured framework for harmonizing heterogeneous physiological data sources in military selection and evaluate unsupervised phenotyping.

METHODS
We built a multimodal dataset from continuous heart rate (HR), beat-to-beat interval (BBI), glucose, morning/evening salivary cortisol, and pre-/post-event body composition data collected during a military selection process and aligned them on a common 5-minute grid. Longitudinal signals were summarized using bin-level statistical and variability features, including HR mean, median, and standard deviation; BBI meanNN, medianNN, SDNN, RMSSD, and pNN50; and glucose central tendency, variability, and short-term change measures. Sparse cortisol samples were aligned through circadian normalization with a mixed-effects baseline model. Missing data were handled using linear interpolation, piecewise cubic Hermite interpolation (PCHIP), and Kalman smoothing, and the impact of these imputation strategies was evaluated using Monte Carlo simulated missing-data validation. Data quality was assessed with a fusion-ready completeness metric, and records meeting a minimum observed-coverage threshold were retained for downstream derivative dynamic time warping (DDTW) based k-medoids clustering.

RESULTS
Interpolation performance depended on signal type and gap length. Kalman smoothing was the most consistently robust method overall and generally performed best for BBI variability features, yielding mean absolute error (MAE) ranges of 14.08-17.81 for SDNN, 6.0-8.3 for RMSSD, and 4.77-6.61 for pNN50, while PCHIP was most consistently best for glucose. Fusion-ready completeness showed substantial inter-individual variability (median 46%, IQR 31–55%). DDTW-based k-medoids clustering showed a strong association with selection outcome, with pass rates of 73.7% versus 29.0% (χ^2=18.91, p=1.37×10^-5).

CONCLUSION
This framework produced an analysis-ready, completeness-aware multimodal dataset and showed that imputation should be signal-specific rather than uniform. Despite substantial variability in fusion-ready completeness, the harmonized data supported phenotyping that was strongly associated with military selection outcome.

MILITARY IMPACT
The workflow makes multimodal field data usable and auditable. This could support more objective monitoring, and improved decision-making in demanding training and selection environments

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#47101701
Poster Presentation

Biological sample processing in a temporary field laboratory: operational experience from the PENTHERE study

BACKGROUND
Physiological studies conducted in operational environments require biological sampling under constrained field conditions while maintaining analytical quality compatible with laboratory standards. Unlike deployable medical laboratories used during military operations, which rely on established infrastructure, research field laboratories must operate directly on the training site with limited access to electricity, controlled environments, and water of sufficient purity for biological procedures. The PENTHERE study provided the opportunity to implement a temporary field laboratory and develop a biological sampling and processing strategy adapted to these constraints.

METHODS
During the PENTHERE study, biological samples from 12 participants were collected and processed within a short time window. A structured workflow was implemented to coordinate sampling and laboratory procedures while respecting laboratory good practices. Venous blood samples were centrifuged immediately after collection to separate plasma and cellular fractions. Samples were then aliquoted and rapidly frozen before transportation to a reference laboratory for subsequent analyses. This strategy allowed rapid processing of multiple subjects while ensuring optimal pre-analytical conditions. Certain point-of-care analyzers were not suitable because their analysis time per parameter would have significantly increased the overall processing time.

RESULTS
The implemented workflow enabled efficient processing of multiple participants while preserving sample integrity and ensuring appropriate conditions for subsequent laboratory analyses.

CONCLUSION
This experience highlights the specific challenges of conducting biological investigations in field environments, particularly regarding reliable electricity supply, access to water of adequate purity, and maintenance of clean working conditions. The management of the cold chain also represents a critical constraint, requiring portable freezing solutions capable of rapidly stabilizing biological samples and maintaining low temperatures during storage and transport.

MILITARY IMPACT
These findings contribute to the development of lightweight deployable research laboratories capable of supporting physiological monitoring during military training and field studies.

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Thematic 11 :
Heat, Themal Strain, and Physiological Monitoring : From sensing to prediction and real time risk mitigation in operational environment

#47156398
Poster Presentation

Improving the accuracy of energy expenditure estimates by utilizing a heat flux sensor in wearable devices

Most military tasks are performed under low to moderate physical load (Pihlainen et al. 2014), whereas environmental temperatures may vary on both sides of the thermoneutral zone (Patton et al. 2025). Energy expenditure during performance is affected by the intensity and mechanical efficiency of the activity, with the remaining energy primarily dissipated as heat. This heat flux from the body can be measured at the skin surface using a heat flux sensor integrated into a wearable device, which can potentially improve the accuracy of the device's energy expenditure estimates.

The study was conducted in three different ambient temperatures (10, 20, and 30 °C). In each environment, participants completed three cycling workloads corresponding to 20, 30, and 40% of their estimated (Jackson et al. 1990) individual maximal oxygen uptake. The order of workloads and environmental temperatures was randomized for each participant. The study included nine participants: four men (23.8 ± 1.3 yrs., 79.9 ± 11.6 kg, 180.8 ± 9.7 cm, physical activity 6.8 ± 0.5) and five women (22.2 ± 2.3 yrs., 63.9 ± 5.1 kg, 167.2 ± 7.1 cm, 6.6 ± 0.9). Energy expenditure was measured using indirect calorimetry, simultaneously heart rate, core temperature, and heat flux were recorded. The heat flux sensor was attached to the skin over the left radial artery using an adhesive suitable for skin contact. The validity of the machine learning model was evaluated using a leave one out method.

Ambient temperature influenced the measured heat flux, when values were higher at temperatures below thermoneutrality (20 °C and 10 °C; $p < 0.05$) compared to 30 °C, and a significant difference was also observed between 20 °C and 10 °C ($p < 0.05$). Environmental temperature also affected heart rate, which was higher at 30 °C than at 10 °C ($p < 0.05$) and 20 °C ($p < 0.01$). However, ambient temperature had no effect on energy expenditure or core temperature. In the machine learning analysis, adding ambient temperature information to the model actually increased prediction error. When all inputs were used, the median error relative to indirect calorimetry was 14.1% with a range of 37.8 percentage points.

Relatively small error was achieved using background variables combined with heat flux data alone (median error 9.7%, range 25.7 percentage points). However, the smallest error was obtained when only background variables and heart rate were included (excluding ambient temperature and heat flux data) yielding a median error of 9.6% and a range of 24.5 percentage points.

The results show, as expected, that the heat flux signal depends on the temperature gradient between the skin and the environment. Heat flux reflects the amount of thermal energy dissipating through the skin surface measured over the sensor area and generalized to the whole body. The aim of the study was to develop a generic energy expenditure prediction model for both men and women, but this introduced heterogeneity into the dataset, likely affecting both skin surface area and the amount of active muscle mass contributing to energy expenditure. Consequently, incorporating more detailed background information into the model could potentially improve the accuracy of energy expenditure estimation based on the heat flux signal.

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Thematic 12 :Non-technical skills in high-intensity conflicts + Ethics regarding performance in High-Intensity Conflicts

Le Grand Salon - Mod: A. Vacher + L. Chaudet + M. Trousselard + N. Pattyn

ORAL PRESENTATIONS

Development of a Technology Assessment Tool for Human Performance Augmentation in Defence Contexts

Dreamwork Makes the Teamwork: Sleep, Team Processes, and Operational Health in Naval Deployment

Effect of physicians' experience on emotional competencies during prehospital management of severely injured patients

POSTER PRESENTATIONS

Evolution of Military Strategies: From the Napoleonic Wars to the Rise of Robotic Infantry

Thematic 12 :
Ethics regarding performance in high-intensity conflicts

#46746258
Oral Presentation

Development of a Technology Assessment Tool for Human Performance Augmentation in Defence Contexts

BACKGROUND

Human Performance Augmentation (HPA) technologies present both significant opportunities and complex challenges for Defence organizations seeking to enhance capability, readiness, and operational effectiveness. Currently there are no existing comprehensive systematic approaches that support decision makers in understanding the potential risks and benefits of developing and implementing HPA technologies for Defence. The Human Factors and Medicine Research Task Group (HFM-365) aimed to develop a structured and adaptable tool for decision making related to research, development, acquisition and/or implementation of HPA technology in Defence, suitable for application across all member states.

METHODS

The development process included a review of existing assessment frameworks either for Defence or specifically for HPA, establishing a rationale for dimension selection, iterative refinements informed by NATO member state workshops, and formulating recommendations for effective use. Drawing on existing Defence-specific and civilian technology assessment frameworks, including tools from the Swedish Defence Research Agency, Netherlands Organization for Applied Scientific Research, Defence Science and Technology Laboratory, World Health Organization and NASA's Technology Readiness Levels, and Human Readiness Levels, the working group synthesized best practices into a tailored Defence-focused framework that addresses technological, human, operational, and security considerations.

RESULTS

Five core dimensions were identified as essential for evaluating HPA technologies: Needs & Drivers, Practical Applicability, Availability, Effect & Impact, and Security. The tool integrates binary and open-ended questions to support structured expert judgment and enables multidisciplinary panels to formulate evidence-informed recommendations regarding research, acquisition, or implementation pathways.

The tool focuses on dimensions that can be assessed systematically using quantitative or semi-quantitative information. Ethical, legal, and social aspects (ELSA) were acknowledged but not included as core dimensions, as they typically require a separate, context-specific review. However, the tool's findings provide a clearer basis for judging whether a dedicated ELSA assessment is warranted.

CONCLUSION

The resulting tool offers a flexible yet thorough approach to guide Defence stakeholders in responsibly advancing HPA technologies while accounting for national contexts and HPA-specific challenges.

MILITARY IMPACT

HPA and its role in high intensity conflict must continue to be explored. This tool provides 'guardrails' to the discussion on whether a certain HPA technology should be researched further, implemented in training or operations, recommended for civilian market monitoring, or dismissed as irrelevant to Defence needs.

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Thematic 12 :
Non technical skills and interpersonal factors in high-intensity conflicts

#46661879
Oral Presentation

Dreamwork Makes the Teamwork: Sleep, Team Processes, and Operational Health in Naval Deployment

BACKGROUND
Sleep disruption and teamwork are inherent features of 24/7 operational environments, yet remarkably little is known about how sleep affects the execution of team skills, and if functional teamwork mitigates the negative effects of poor sleep on operational health and readiness. To explore these relationships, we examined daily sleep, multiple team processes, and operational health outcomes in the crews of four US Navy Destroyers as part of a deployed Carrier Strike Group.

METHODS
We analyzed data from 534 active-duty US Sailors (82% male, mean ± SD age 28 ± 7 yr). Daily sleep duration (total sleep time) was recorded using Oura ring wearable devices (Gen4). Surveys were administered at 4–5 months into deployment, where we assessed Sailors' perception of their primary work team's (Division) execution of team Transition processes (identify challenges, ensure understanding of goals, develop strategies), Action processes (monitor environment and performance, coordinate. communicate, assist each other), and Interpersonal processes (manage conflicts fairly, encourage others, maintain emotional balance). Operational health and readiness outcomes included self-reported decrements in physical health (number of days in previous 30 with physical illness or injury) and mental health (number of days in previous 30 with stress, depression, or emotional problems). All numerical variables were log10 transformed, and we performed a path analysis examining direct relationships between mean daily total sleep time and team transition, action, and interpersonal processes; direct relationships between sleep and physical and mental health; and moderation effects between sleep, team processes, and operational health outcomes. Age and sex were included as control variables.

RESULTS
The path model yielded moderate to good fit ($\chi 2 = 1095$, $p < 0.001$; RMSEA = 0.83; CFI = 0.16; SRMR = 0.19). Controlling for age and sex, there were direct positive relationships between sleep and team action processes ($\beta = 0.11$, $p = 0.014$) and interpersonal processes ($\beta = 0.09$, $p = 0.033$); direct relationships between sleep and mental health ($\beta = -0.10$, $p = 0.012$); and a direct relationship between team interpersonal processes and mental health ($\beta = -0.23$, $p = 0.003$). The effects of sleep and team processes on health were independent, with no moderating effects of team processes on sleep-health relationships (absolute β's < 0.02, p's > 0.10).

CONCLUSION
Good sleep health may support effective teamwork and mitigate mental health risks in high-stress operational environments.

MILITARY IMPACT
Teamwork is a core function of military operations. Support for sleep health at the individual and unit levels may not only benefit individual health and readiness, but also sustain the teamwork skills critical to mission success.

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Thematic 12 :
Non technical skills and interpersonal factors in high-intensity conflicts

#46808044
Oral Presentation

Effect of physicians' experience on emotional competencies during prehospital management of severely injured patients

BACKGROUND
In the context of high-intensity conflicts, the prehospital management of severely injured patients is highly demanding, requiring physicians to rapidly assess the casualty's condition, make critical decisions, and coordinate team actions in order to maintain vital functions and organize evacuation, often under extreme time pressure. A major safety concern relates to the reduction of preventable deaths, estimated at approximately 24.3% among injured casualties (Eastridge et al., 2012).However, recent research has highlighted the importance of the emotional dimension in prehospital healthcare (Backström & Alvinius, 2024). Therefore, emotional competencies, defined as the ability to identify, express, understand, and regulate emotions—both one's own and those of others—represent a promising avenue for enhancing healthcare training (Mikolajczak et al., 2023), as experimental studies have demonstrated that novice physicians with higher levels of emotional competencies achieved better performance scores when managing sudden patient deterioration (Bourgeon, 2016). Investigating how emotional competencies are deployed during prehospital care remains a gap in the literature. This issue is particularly relevant across the professional lifespan, as previous research has shown that certain emotional competencies, such as empathy, may decline with increasing experience (Bellini & Shea, 2005). The present study therefore pursued two objectives: (1) characterize the deployment of emotional competencies during prehospital management of severely injured patients, and (2) examine whether professional experience influences this deployment.

METHODS
Twenty-six physicians (13 women, 13 men; age 28–59 years; experience 3 months–35 years) participated in the study. Semi-structured interviews were conducted using the Critical Decision Method (Klein & Armstrong, 2004) within 24 hours following a shift. This method is designed to elicit decision-making processes in dynamic and complex situations through the use of structured probes. Specifically for our study, probes targeting the emotional dimension were incorporated to explore emotions experienced by the physician and team members, and emotion regulation during the event. Intervention- and emotion-related variables were collected.

RESULTS
The reported interventions predominantly involved road traffic accidents (54%), weapon-related penetrating injuries (38%), and falls from significant height (8%). Thirty-one percent of the cases were "life-threatening emergencies", 50% were classified as "absolute emergencies", and 19% as "non–life-threatening emergencies". The emotion-related variables are currently being analyzed. Final results will be presented at the oral communication.

CONCLUSION
This study aims to provide novel insights into how physicians deploy emotional competencies during prehospital care of severely injured patients and how professional experience may influence this deployment. The findings are expected to inform training programs designed to enhance team performance and patient safety in high-intensity conflicts.

MILITARY IMPACT
Effective prehospital care is a critical component of battlefiled medicine, with 24% of deaths potentially preventable. Understanding emotional competencies deployment can guide training, to improve decision-making and team coordination, ultimately enhancing effective prehospital care.

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Thematic 12 : Ethics regarding performance in high-intensity conflicts

#46786133
Poster Presentation

Evolution of Military Strategies: From the Napoleonic Wars to the Rise of Robotic Infantry

BACKGROUND

From the Napoleonic Wars to the possible advent of robotic infantry in the 21st century, military strategies have constantly evolved under the influence of technological innovation. The study of the evolution of military strategies is of paramount importance due to the intrinsic link between technological innovation and the transformation of armed conflicts. This understanding is essential for anticipating the dynamics of future conflicts, in which technology will play an increasingly decisive role. It is therefore from this perspective of robotization that we analyze military strategies in order to shed light on the most contemporary dynamics.

METHODS

Our method is based on a historical analysis highlighting continuities and transformations up to the present day, combined with a forward-looking approach to explore possible scenarios for military strategies in a context of increasing robotization. The analysis aims to identify the strategic, ethical, and geopolitical issues involved. Our work is grounded in a literature review; numerous scholars in military technologies and historians have informed our analysis and strengthened our hypotheses regarding future prospects.

RESULTS

The Second World War marked a major turning point in the history of conflicts. The doctrines that emerged during this period—such as German blitzkrieg and Soviet defense—illustrate the growing complexity of modern warfare. Yet the end of this global conflict opened a new era in which direct confrontation gave way to strategic competition. The Cold War, characterized by a race for technological superiority and deterrence, redefined the rules of military engagement and laid the foundations for contemporary conflicts. The two superpowers invested in increasingly sophisticated weapons: intercontinental ballistic missiles, nuclear-powered ballistic missile submarines, spy satellites...

Electronic warfare and cybernetics have emerged as new forms of combat, designed to disrupt enemy systems and protect strategic infrastructure; a central role is devoted to intelligence and psychological warfare, with control of information occupying a key position in military doctrines. Mastery of the human terrain became essential, as did the ability to conduct unconventional operations: drones, covert operations, cyberattacks, and psychological warfare. These conflicts required new levels of versatility and flexibility, breaking with the large-scale frontal battles of the past. Modern armed forces anticipate entirely new forms of conflict shaped by the digital revolution and automation. The integration of AI and drones into military systems is fundamentally reshaping tactical and strategic decision-making. However, the war of the future will not be fought solely on physical battlefields; it is also unfolding in the invisible and interconnected domains of cyberspace and information. The future military strategy is an integrated system combining technological power, control of information, and cognitive superiority. Future conflicts will be won with algorithms, networks, and the ability to dominate simultaneously the physical, virtual, and psychological domains.

CONCLUSION

Our results corroborate the analyses of R. Sparrow regarding the dehumanization of combat and the erosion of responsibility. They also align with the concerns expressed by Human Rights Watch and the Stop Killer Robots coalition about the urgent need for a normative regulatory framework.

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Thematic 13 : Heatstroke: prevention and management

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ORAL PRESENTATIONS

Clinical Practice Guideline for the Prevention, Diagnosis, and Management of Exertional Heat Illness

Half a Decade of Heat Injuries in the IDF: Key Insights and Lessons Learned (2021-2025)

Quantifying Relative Importance of Risk Factors for Exertional Heat Illness

Longitudinal DNA Methylation Analysis Reveals Divergent Epigenetic Trajectories in Recovery and Pathology of Heat Illness

Thermoregulation in heat stroke individuals: what does the heat tolerance test really tell us?

POSTER PRESENTATIONS

Using machine-learning models for military heat illness diagnosis and hospitalisation requirement during initial entry operations conducted in extreme heat

The influence of muscle damage on subsequent thermoregulatory responses in a standardised heat stress test involving arm cranking and cycling

Training in the Shadow of War: Exertional Heat Illness During the "Iron Swords" War

Cardiac troponin in soldiers recovering from exertional heat stroke: a viewpoint on return-to-duty

Half a Decade of Insights from Military Tryouts: Mitigating Physiological and Environmental Exercise-Related Injuries

Comparison of physiological data from heat tolerant and heat intolerant patients at the British Military Heat Illness Clinic

Motivation and sensorial-perceptive factors examined within a cost-benefit framework in exertional heat stroke

Cutaneous vascular conductance and cardiac autonomic responses to heat tolerance testing

Thematic 13 : Heatstroke: prevention and management

#46494773
Oral Presentation

Clinical Practice Guideline for the Prevention, Diagnosis, and Management of Exertional Heat Illness

BACKGROUND
Exertional heat illness (EHI) continues as a significant threat in the US Military with nearly 3,000 reported cases in 2024. As EHI can be associated with significant morbidity and mortality, the utilization of best practice recommendations is critical for operational readiness. In addition, despite Service-spe¬cific guidance on the recognition and management of EHI, diagnosis and management remain challenging. Additionally, there has been no joint consensus on guidelines for treatment in the prehospital, emergency room, inpatient hospital, and intensive care settings.

METHODS
This military-specific clinical practice guideline (CPG) was developed by US Joint Service military medi¬cal providers, in conjunction with The Army Heat Center and the Consortium for Health and Military Performance (CHAMP) Warrior Heat- and Exertion-Related Event Collaborative (WHEC), to identify and disseminate the clinical best practice in the prevention, management, and return to duty of SM afflicted with EHI.

RESULTS
Management of EHI represents a well-organized chain of survival, including prehospital field care; emergency care; advanced care, to include hospital care; and, finally, return to duty. This integrated system relies on communication to optimize service member (SM) care, and to minimize morbidity, mortality, and impact on unit readiness. The cornerstone of manage¬ment is the identification of the SM at risk for EHI, and the provision of on-site and effective cooling. This CPG details effective cooling measures at each level along the chain of survival (e.g., prehospital field, emergency medical services transport, and emergency department) and details the ex-pected time course of co-morbidities to facilitate optimal decision-making for life-saving management. Return to duty (RTD) represents the final management stage of the SM with EHI and hinges on the critical role of the military medical provider. RTD recommendations are challenging given the highly individualized nature of EHI events.

This CPG outlines an evidence-based risk-stratifi¬cation process for EHI severity, with appropriate guidance for return to duty.

CONCLUSION
This CPG represents the first US Joint Service collaborative effort to establish consensus around EHI prevention, diagnosis, management, and return to duty, while recognizing the diverse missions of the branches of the Armed Forces.

MILITARY IMPACT
This military-specific CPG has been developed by Joint Service military medi¬cal providers, in conjunction with The Army Heat Center and the CHAMP WHEC, to identify and disseminate the clinical best practice in the prevention, management, and return to duty of SM afflicted with EHI. This CPG identifies recommendations intended to optimize SM care that are informed by a review of current evidence and clinical experience.

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Thematic 13 :
Heatstroke: prevention and management

#46484688
Oral Presentation

Half a Decade of Heat Injuries in the IDF: Key Insights and Lessons Learned (2021-2025)

BACKGROUND
In the Israel Defense Forces (IDF), service members who experience exertional heat illness (EHI) must undergo medical evaluation at the Institute of Military Physiology before returning to duty. This study characterized the epidemiology of EHI over five years and identified risk factors differentiating Exertional Heat Stroke (EHS) from less severe injuries.

METHODS
Medical records of 279 soldiers diagnosed with EHI between 2021 and 2025 were retrospectively analyzed. Cases were classified as Exertional Heat Stroke (EHS, n=89) or Non-Severe Exertional Heat Injury (NSEHI, n=190). Continuous variables were compared using independent sample t-tests and categorical variables using chi-square tests.

RESULTS
EHS accounted for 32% of cases. Field rectal temperature was higher in EHS vs. NSEHI (40.0±1.2°C vs. 38.8±0.8°C, $p<0.01$). Summer months (June-September) accounted for 56% of injuries and 69% of EHS. An inverse relationship was observed between case volume and severity ($p<0.01$). Basic and advanced training accounted for 59% of cases, mostly mild, with 28% classified as EHS. Pre-enlistees had the lowest severe injury rate (15%). Active-duty soldiers and cadets had fewer total events but higher proportions of EHS (53% and 46%). Marches produced the highest number of injuries (38%), while high-intensity fitness activities showed the greatest severity (46% EHS, $p=0.025$). Operational injuries remained rare (<5%). Insufficient sleep (39% vs. 23%, $p<0.01$) and exceeding effort limits (21% vs. 6%, $p<0.01$) were more common in EHS, as were heat load mismatch and delayed recognition of underperforming soldiers. Nutrition, acute illness, and hydration deficits showed similar prevalence between groups. EHS cases had greater cumulative risk factors (1.7±1.2 vs. 1.3±1.3, $p=0.01$).

CONCLUSION
While most heat injuries occur early in service, severity increases in later stages. Close supervision during basic training may facilitate early recognition and mitigation. In contrast, reduced supervision combined with high motivation among experienced soldiers may contribute to fewer but more severe events.

MMITARY IMPACT
Commanders should recognize that experienced soldiers may be at greater risk for life-threatening EHS as supervision decreases with seniority. Preventive strategies should therefore maintain rigorous heat-injury vigilance in advanced training and operational units, addressing the assumption that experience alone confers protection against EHI.

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Thematic 13 :
Heatstroke: prevention and management

#46727735
Oral Presentation

Quantifying Relative Importance of Risk Factors for Exertional Heat Illness

Heat-related illnesses pose significant risks for individuals who perform physical activity in the heat. To date, most risk factor analysis has been performed via retrospective review of medical records.

The purpose of the present study was to evaluate risk factors from individuals who presented to the emergency department (ED) at Martin Army Community Hospital at Ft. Benning, GA and were diagnosed with a heat-related illness including heat exhaustion (HE), heat injury (HI), or exertional heat stroke (EHS).

We evaluated the risk factors in three categories: individual (illness risk, fitness, body mass index), environmental (wet-bulb globe temperature, WBGT), and activity-specific (load carriage, clothing). Linear mixed effects models were calculated to evaluate the relative influence of each risk factor on the relative risk for developing one of the heat-related illnesses over the others.

A total of 141 heat illness cases (n=15 female) presented to the ED and volunteered to participate in this investigation (n=58 HE, n=22 HI, n=61 EHS). An average of 3 primary and 7 secondary risk factors were quantified for each heat illness category. A majority of EHS casualties presented to the ED euhydrated (84%) and 64% of all cases occurred in environmental conditions < heat category 1.
Out of all individuals who developed a heat illness, we observed a significant increase in risk for EHS over HE and HI for higher BMI (>28 kg•m2, $p<0.05$) and an increased risk for EHS with younger age ($p<0.05$).

These findings suggest that individualized (i.e., BMI) and activity-specific (i.e., load carriage) risk factors are the most frequently occurring and are potentially modifiable to optimize performance with lower risk. Supported by USAMRDC; author views not official US Army or DoW policy.

AUTHORS

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Thematic 13 : Heatstroke: prevention and management

#46777534
Oral Presentation

Longitudinal DNA Methylation Analysis Reveals Divergent Epigenetic Trajectories in Recovery and Pathology of Heat Illness

BACKGROUND
Exertional heat stress causes a spectrum of illnesses, ranging from mild heat exhaustion to life-threatening heat stroke. While epigenetic mechanisms, such as DNA methylation, are thought to influence heat acclimation and recovery, the molecular changes that define the severity and progression of heat illness remain poorly understood. This study aimed to characterize and compare the longitudinal dynamics of DNA methylation in peripheral blood across the clinical spectrum of exertional heat illness.

METHODS
A cohort of 87 individuals diagnosed with heat exhaustion (n=32), heat injury (n=16), or heat stroke (n=39) was studied. Whole-blood DNA methylation profiles were assessed at the time of diagnosis and across four subsequent time points representing acute, sub-acute, and later recovery phases. Differential methylation analysis, time-course clustering, and pathway enrichment were used to identify epigenetic changes and their associated biological pathways.

RESULTS
At diagnosis, heat stroke and heat injury exhibited thousands of differentially methylated probes compared to heat exhaustion, with most changes being unique to each condition. Longitudinal analysis revealed that methylation profiles in heat exhaustion normalized rapidly, indicating a quick recovery. In contrast, heat injury showed transient activation of pathways related to neuronal protection, stress regulation, and adaptive immunity, followed by sustained suppression of synaptic and T-cell signaling pathways, suggesting a resource-conserving recovery state. Heat stroke was characterized by delayed and persistent activation of maladaptive pathways, including inflammasome activation, proteotoxic stress, and oxidative strain, reflecting a progression toward systemic immune and cellular dysfunction.

CONCLUSION
Heat illness severity is associated with distinct and persistent epigenetic trajectories in peripheral blood. While heat injury is marked by adaptive methylation programs that promote recovery, heat stroke triggers pathological signatures of systemic inflammation and cellular stress. These findings provide a molecular framework for understanding heat illness progression, identify potential biomarkers for predicting clinical outcomes, and highlight therapeutic targets to mitigate long-term complications.

MILITARY IMPACT
Heat illness is a significant concern for military personnel operating in extreme environments. This study identifies epigenetic biomarkers that could enable early detection of severe heat illness and guide personalized treatment strategies. By understanding the molecular mechanisms underlying recovery and pathology, these findings can inform the development of interventions to improve health outcomes and operational readiness in military settings.

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Thematic 13 : Heatstroke: prevention and management

#46809643
Oral Presentation

Thermoregulation in heat stroke individuals: what does the heat tolerance test really tell us?

BACKGROUND
Exertional heat stroke (EHS) occurs under heterogeneous circumstances. Most cases are associated with several intrinsic or extrinsic risk factors (simple EHS), whereas a minority occur without evident risk factor or are recurrent episodes (complex EHS). The Israeli Heat Tolerance Test (HTT) is widely used to guide return-to-duty decisions, although its indications and physiological interpretation remain debated. This study aimed to (1) compare thermoregulatory responses among simple and complex EHS and (2) identify limitations of the HTT using heat balance analysis.

METHODS
Fifty-six military personnel were included: 18 controls (CONT), 21 with simple EHS (SIMP-EHS) and 17 with complex EHS (COMP-EHS). All participants performed the HTT, which consisted of two hours of treadmill walking in an environmental chamber set at 40°C and 40% relative humidity. Rectal temperature (Trec), skin temperature (Tskin), and respiratory gas exchange were continuously recorded. Classical heat balance equations were used to calculate required evaporative heat loss (Ereq), maximal evaporative capacity (Emax), and skin wettedness.

RESULTS
Heat intolerance, defined as a final Trec >38.5°C without plateau, was observed in 39% of CONT, 33% of SIMP-EHS, and 65% of COMP-EHS participants. Final Trec was significantly higher in COMP-EHS (38.8±0.63°C) compared with CONT (38.3±0.42°C; p=0.021) and SIMP-EHS (38.3±0.52°C; p=0.009). Taking all participants together, mean metabolic heat production (Hprod) was approximately 5.3W·kg^{-1} but showed substantial inter-individual variability (4.0–8.0W·kg^{-1}) and was not associated with anthropometric characteristics nor EHS subcategorization. Heat-intolerant individuals exhibited higher Hprod relative to body surface area than tolerant individuals. Mean skin wettedness reached 0.83, with large inter-individual variability (0.55–1.30), and was not associated with anthropometric characteristics nor EHS subcategorization.

CONCLUSION
Thermoregulatory responses in simple EHS were comparable to those of controls, whereas complex EHS cases exhibited a distinct pattern characterized by greater Trec. Although the HTT standardizes external workload and environmental stress, it induces highly variable internal thermal loads. On average, HTT conditions positioned participants near the limit of heat compensability, with a substantial proportion exceeding compensable thresholds typically described for non-acclimatized individuals. These findings indicate that the HTT challenges some individuals close to or above their compensability limits, while for others the imposed stress remains well below their thermoregulatory capacity. Consequently, relative heat strain, and thus the degree of challenge to thermolysis, can differ markedly between subjects despite identical external conditions. Thus, the interpretation of HTT results as a direct scale of involuntary thermoregulatory function should be approached with caution. Heat intolerance observed during the HTT is useful for estimating the risk of heat illness during group performance at a fixed absolute intensity. However, intolerance should not be systematically interpreted as evidence of impaired thermoregulation.

MILITARY IMPACT
HTT appears particularly relevant for identifying heat vulnerability in individuals with complex EHS. However, its use as a diagnostic tool for impaired thermoregulation requires methodological refinement.

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Thematic 13 : Heatstroke: prevention and management

#1000057
Poster Presentation

Using machine-learning models for military heat illness diagnosis and hospitalisation requirement during initial entry operations conducted in extreme heat

BRACKGROUND

The past decade was the hottest on record, with more frequent, prolonged and severe heat events increasing the global burden of heat-related morbidity (HRM). Regions of the world affected by extremes of thermal stress are of continuing relevance to international military organisations. A spectrum of HRM severity is described, with increasing thermal strain precipitating heat exhaustion, and central nervous system (CNS) dysfunction heralding the onset of life-threatening heatstroke. However, exposure to severe disease and clinical experience of HRM management may be lacking in parts of the military workforce, meaning that diagnostic uncertainty, limited escalation protocols, and mass casualty burden could overwhelm deployed medical capability. We analysed historic operational HRM data in order to characterise more severe heat Illness (HI, heat exhaustion + heatstroke) and lesser states of heat stress (HS, including heat hyperventilation, heat cramps, and heat intolerance) and clarify hospitalisation risk, in order to develop a machine-learning model for triage decision support.

METHODS

Clinical records from 298 UK military HRM casualties presenting to a dedicated pre-hospital HRM treatment facility during acclimatisation in Kuwait were reviewed. 197 complete cases with 21 predefined clinical features were included, then dichotomised according to the diagnoses assigned by clinical teams experienced in HRM management (HI vs HS). Fisher's exact testing identified associations with HI diagnosis and hospitalisation risk. Respective odds ratio (OR) and relative risk (RR) were determined for clinical features using Baptista-Pike and Koopman asymptotic scores. Decision-tree machine learning models were trained on 70% of cases ("creation set") and tested on 30% ("testing set") to predict HRM diagnosis and hospitalisation requirement.

RESULTS

Diagnosis was HI in 43.2% of HRM presentations, and the hospitalisation rate (HI + HS) was 16.8%. Significant predictors of hospitalisation included loss of consciousness (OR 5.37), collapse (OR 4.70), hyperthermia >38°C (OR 2.48), and assignment of HI diagnosis (OR 3.21). Predictors of HI included collapse (OR 3.78), loss of consciousness (OR 6.94), hyperthermia (OR 56.06), and tachycardia (OR 3.74). Machine-learning prediction accuracy was 93.9% for HI vs HS discrimination and 83.7% for hospitalisation outcome.

CONCLUSION

Decision-tree modelling accurately stratified operational heat causalities using readily observed clinical variables. Collapse, loss of consciousness, and hyperthermia strongly predict both HI and hospitalisation requirement. Escalation of suspected HI by first responders should prioritise rapid identification of collapse in the medical history, and impaired consciousness in the initial assessment. In discerning hospitalisation need, clinicians unfamiliar with HRI should identify ongoing hyperthermia, but give at least equal weighting to neurological and cardiovascular embarrassment. Machine learning may aid both steps in HRM triage.

MILITARY IMPACT

As global temperatures rise, rapid identification and differentiation of HRM is essential for preserving fighting strength and preventing saturation of deployed medical assets. This machine learning model may support non-specialist clinicians during large-scale heat casualty events by assisting clinical diagnosis and need for escalation in austere environments.

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Thematic 13 : Heatstroke: prevention and management

#46710519
Poster Presentation

The influence of muscle damage on subsequent thermoregulatory responses in a standardised heat stress test involving arm cranking and cycling

BACKGROUND
This study was undertaken to test the hypothesis that muscle damaging exercise increases heat strain during subsequent exercise in a warm environment and may therefore be a factor in the development of heat illness.

METHODS
The thermoregulatory responses to a heat stress test of participants (n = 6) with exercise induced muscle damage (EIMD) invoked by 60 min loaded downhill walking on a treadmill, were compared to matched participants in a control condition (CON) (n = 6) walking on a treadmill at 1% gradient. The participants were matched for body mass, aerobic fitness and body surface area. The heat stress test involved 20 min arm cranking immediately followed by 40 min cycling both at 50% VO2peak in a warm environment (34 °C and 50% relative humidity), and was undertaken several days before (HST1), 60 min post (HST2) and 25 hours post (HST3) treadmill walking. The thermal responses were deliberately assessed using different modes of exercise from the initial damaging exercise to avoid the confounding influence of gait or efficiency changes on metabolic heat production from systemic inflammatory mediated effects.

RESULTS
Loaded downhill walking successfully induced muscle damage as determined by greater increases in serum myoglobin and creatine kinase concentrations and subjective pain scores, and a greater reduction in the 20:50 Hz ratio leg strength measurement in EIMD than CON pre to post treadmill walking (all $p < 0.05$). The increased creatine kinase and subjective pain scores persisted the following day (measured pre-HST3). EIMD participants also had a greater interleukin-6 (IL-6) response, with post HST2 mean (SD) values of 2.94 (0.65) pg.mL-1 for EIMD and 1.45 (0.69) pg.mL-1 for CON, ($p < 0.01$). Regarding thermoregulatory response, there was an effect of condition ($p = 0.05$ and condition × time interaction ($p = 0.04$) on the rate of rise of rectal temperature during cycling, which was higher for EIMD than CON during HST2 and HST3.

During cycling the mean (SD) rates of rise rectal temperature for EIMD were 1.31 (0.27) °C.hr-1 in HST1 and 1.48 (0.27) and 1.47 (0.42) °C.hr-1 in HSTs 2 and 3, compared to 1.13 (0.21), 1.16 (0.26) and 0.97 (0.18) °C.hr-1 respectively for the three HSTs for CON. There was a moderate association between the rate of rise of rectal temperature during cycling in HST2 and both the post-HST2 IL-6 concentration ($r = 0.63$, $p = 0.03$) and the pre-treadmill exercise to post-HST2 delta IL-6 response ($r = 0.611$, $p = 0.04$). However, for HST3 IL-6 concentration had returned to baseline and was not associated with rectal temperature. For arm cranking there was an effect of time on the rate of rise of rectal temperature ($p = 0.05$) for both EIMD and CON but no condition or interaction effects.

CONCLUSION
In practical terms the results of this study support the hypothesis that muscle damage may increase thermal strain during subsequent exercise if exercising with the same muscle groups as involved in the muscle damaging exercise; but does not if exercising with different muscle groups.

MILITARY IMPACT
Thermal strain and therefore possibly the risk of developing heat illness during exercise in a warm environment could be increased for at least 25 hours after undertaking muscle damaging exercise when the exercise involves the same muscle groups.

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Thematic 13 : Heatstroke: prevention and management

#46488664
Poster Presentation

Cardiac troponin in soldiers recovering from exertional heat stroke: a viewpoint on return-to-duty

BACKGROUND
Strenuous physical exercise is a cornerstone of exertional heat stroke (EHS), the most severe condition within the spectrum of exertional heat illness and constitutes a life-threatening medical emergency. Although the clinical presentation EHS is that of multiorgan failure, cardiac troponin (cTn), a biomarker of cardiac injury, is rarely measured in these patients. Questions arise regarding the clinical significance and potential long-term implications of elevated circulating cTn in EHS patients, as well as their relevance for decision-making related to return to duty or activity (RTD/A) of soldiers recovering from EHS. The increase in cTn levels following strenuous exercise, in the absence of overt myocardial pathology, is commonly referred to as "exercise-induced troponin release". The considerable interindividual variability in the magnitude of cTn elevation following exercise is likely related to the overall cardiac workload (the product of both duration and intensity). A similar pattern is observed in EHS. EHS-related cTn kinetics differ substantially from that observed in myocardial infarction and closely resemble exercise-induced cTn kinetics. In EHS, cTn exhibits a monophasic, transient pattern, characterized by a rapid rise that typically peaks at 3–6 hrs., followed by a decline and often complete normalization within 24 to 72 hrs. In contrast, myocardial infarction or myocarditis is associated with a biphasic pattern, with peak cTn levels occurring approximately 24 hrs. after symptom onset and sustained elevation lasting at least 4–7 days. ECG changes in EHS are variable and often nonspecific. These changes may mimic acute myocardial ischemia but typically occur in the absence of obstructive coronary artery disease. Reported abnormalities may include atrial fibrillation, ST-segment elevation or depression, and nonspecific T-wave changes.

CONCLUSION
cTn elevation in EHS can be considered a physiological response secondary to hyperthermia and systemic stress, rather than an indicator of primary cardiac pathology. Accordingly, elevated cTn levels should be interpreted within the clinical context rather than as definitive evidence of myocardial infarction. Routine cTn testing is not warranted in cases of EHS unless specific clinical signs, symptoms, or findings suggest cardiac involvement.

MILITARY IMPACT
Given that soldiers are typically young, healthy, and physically active, cardiac assessment should begin with a 12-lead ECG. In the absence of ECG abnormalities, further cardiac testing, including cTn measurement, is unnecessary, and in this regard RTD/A may be approved. Persistent ECG abnormalities or sustained cTn elevation warrant sequential cTn measurements until resolution. Only in patients with persistent ECG abnormalities or sustained cTn elevation further cardiac workup is advocated, including, echocardiography, exercise stress testing, and coronary evaluation when indicated, prior to RTD/A.

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Thematic 13 : Heatstroke: prevention and management

#46768713
Poster Presentation

Comparison of physiological data from heat tolerant and heat intolerant patients at the British Military Heat Illness Clinic

BACKGROUND
Service personnel in the British Military who have suffered an episode of heat illness are referred to the Heat Illness Clinic (HIC) for a heat tolerance assessment (HTA). Patients are assessed to determine if they can thermoregulate adequately during exercise in warm conditions and return to Operational duties. This study compares the physiological responses of patients deemed heat tolerant (HT) and heat intolerant (HI); and examines physiological responses of patients initially deemed HI and HT at later assessment.

METHODS
The HIC has three stages, a medical consultation, assessment of maximal oxygen uptake ($\dot{V}O_2max$) and HTA undertaken walking on a treadmill with conditions at 34 °C and 44% relative humidity. The HTA consists of three consecutive phases; Phase-1 (30 min) patients wearing combat clothing and carrying a Bergen (mass 14-16 kg) walk to elicit 60% $\dot{V}O_2max$, at 30 min the jacket and bergen are removed (Phase-2) and at 45 min the t-shirt is removed with patients continuing to walk for a further 15-45 min (Phase-3). Patients are considered HT if a plateau occurs in rectal temperature (Tre).

RESULTS
N = 173 first time patients were assessed between Jul 2022 and Aug 2024, n = 145 (84%) were deemed HT and n = 28 (16%) HI; median (min-max) weeks from episode and HIC was 18 (5-168). Anthropometrics and $\dot{V}O_2max$ did not differ between HT and HI patients. HTA Tre was different between HI and HT groups ($P < 0.001$) and groups x time interaction ($P < 0.001$), with higher ($P < 0.05$) Tre in HI patients throughout. The rate of Tre rise was higher ($P < 0.05$) in HI during each phase of the HTA, with median (min-max) rates of rise of 1.9 (1.2-2.9), 1.8 (1.0-2.8) and 1.0 (0.2-1.6) °C.hr-1 in Phases-1, 2 and 3 respectively compared to 1.7 (0.7-3.1), 1.0 (-0.6-2.2) and 0.2 (-1.0-1.4) °C.hr-1 in the HT. Sweat rate and sweat rate relative to body surface area were greater in the HT patients with median (min-max) rates of 1.3 (0.6-3.8) L.hr-1 and 632 (342-1773) mL.m-2.hr-1 compared to 1.0 (0.6-1.6) L.hr-1 and 479 (356-733) mL.m-2.hr-1 for the HI patients ($P = 0.004$ and $P = 0.006$).

Mean skin temperature ($\bar{T}sk$) was greater ($P < 0.05$) in HI patients from minute 15, and heart rate from minute 35 compared to HT patients. N = 10 patients were HI on visit one (V1) and then HT on visit two (V2), a mean (SD) of 18 (7) weeks post V1. There were no differences in their anthropometrics or $\dot{V}O_2max$ between V1 and V2. Despite the same speed, gradient and bergen mass for the HTA at V1 and V2 the percentage of $\dot{V}O_2max$ exercised at in Phases-1 and 2 was lower in V2; mean (SD) values for Phase-1 were 60.8 (1.8)%and 57.9 (3.6)% ($P = 0.02$) for V1 and V2 and for Phase-2 53.0 (2.4) and 50.4 (3.6)% ($P = 0.03$) respectively. Tre was lower at 30, 45 and 60 min (all $P < 0.05$) in V2. The rate of rise of Tre in Phase-3 was lower ($P = 0.03$) in V2, with mean (SD) values of 0.44 (0.45) °C.hr-1 compared to 1.07 (0.30) °C.hr-1 in V1. There were no differences in sweat rate between V1 and V2, 60 min $\bar{T}sk$ was lower ($P = 0.023$) in V2, and heart rate lower at 30 and 45 mins (both $P < 0.05$).

CONCLUSION
Lower sweating responses in HI patients is consistent with higher core temperature and inability to demonstrate thermoregulation. Further work is required to examine the thermodynamic responses of patients recovering from an EHI incident.

MILITARY IMPACT
Military activity places service personnel at greater risk of heat illness, with this report highlighting the requirement for recovery prior to returning to duty and demonstrates the differences in patients deemed HT and HI.

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Thematic 13 : Heatstroke: prevention and management

#46787862
Poster Presentation

Motivation and sensorial-perceptive factors examined within a cost-benefit framework in exertional heat stroke

BACKGROUND
While non voluntary thermophysiological responses are widely studied in exertional heat stroke (EHS), individual factors related to behavioral thermoregulation remain poorly understood even motivation and high stake of trial are commonly recorded. Building on a recently proposed cost-benefit model of effort regulation, this study aimed to examine key psychological and sensorial-perceptive factors factors involved in behavioral thermoregulation in individuals with a history of EHS or not.

METHODS
Fifty-six participants were divided into two groups: eighteen controls with no history of heat illness (controls) and thirty-six individuals with a previous EHS episode (cases). Global and situational motivation, as well as interoceptive sensibility and trait mindfulness were assessed through self-report questionnaires the day before or just before heat tolerance test. A noxious skin heat test was performed to determine noxious threshold. Perceived exertion and thermal sensations were recorded throughout a heat tolerance test.

RESULTS
External aspect of the situational motivation was significantly higher in cases compared to controls ($p<0.001$). Concerning global motivation, the facet of intrinsic motivation related to pleasure experienced during cognitive stimulation was lower in cases compared to controls ($p<0.01$). No between-group difference was observed neither for interoceptive sensibility, mindfulness, noxious threshold, nor for scale of perceived exertion and thermal sensations or for any other global and situational motivation dimensions. As increase of rectal temperature impairs thermal confort and exertion penibility, a subgroup of EHS participants exhibiting greater physiological strain during the HTT with a 0.5°C higher final rectal temperature was studied. While a difference was found in perceived exertion and thermal sensations between tolerant and intolerant subjects, such a difference was not found in this EHS subgroup.

CONCLUSION
These findings indicate that individuals with a history of EHS exhibit a motivational profile characterized by a greater reliance on externally regulated forms of motivation, rather than intrinsic motivation.These findings further support the cost-benefit model of effort regulation in EHS between external contextual factors and intrinsic individual characteristics. Moreover, an impaired perception of bodily signals could also exist in EHS but only obvious in heat intolerant cases.

MILITARY IMPACT
Regardless of individual characteristics, the importance of extrinsic factors of motivation in EHS occurrence should be taken into account for collective prevention. When military instructors give recommandations before training, they must keep in mind that too much stake of trial, command pressure, and competitive spirit in a military team constitute specific risk factors of EHS.

AUTHORS

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Thematic 13 : Heatstroke: prevention and management

#46809218
Poster Presentation

Cutaneous vascular conductance and cardiac autonomic responses to heat tolerance testing

BACKGROUND
During the return-to-duty process following exertional heat stroke, heat tolerance testing (HTT) is used to classify individuals as heat tolerant (HT) or intolerant (HI). Intolerance is defined as the inability to achieve thermal steady state under standardized exercise and environmental conditions. As HTT protocols restrict behavioral thermoregulation, they assess non-voluntary thermophysiological responses to heat stress. However, key responses such as cutaneous vascular conductance (CVC) and heart rate variability (HRV) have not yet been investigated in this context, despite their implication in autonomic thermoregulation. Therefore, this study aimed to compare CVC and HRV responses between HT and HI individuals.

METHODS
Fifty-six military personnel performed the Israeli Defense Forces HTT, which consisted of two hours of treadmill walking in an environmental chamber set at 40°C and 40% relative humidity. Rectal temperature (Trec) was continuously recorded and heat intolerance was defined as a final Trec >38.5°C without plateau. During two 10-minutes periods just before and after the HTT, Trec, local and mean skin temperature (Tskin), CVC and time and frequency domains of HRV were analyzed.

RESULTS
Of all 56 participants, 31 (55%) were classified as HT and 25 (45%) were classified as HI. No differences were observed between groups in any pre-HTT baseline values. Post-HTT, CVC was significantly higher in the HI group compared with the HT group ($p<0.05$); however, this difference was eliminated when local probes were heated to 42°C. All HRV indices analyzed were significantly lower in the HI group than in the HT group post-HTT ($p<0.001$). Post-exercise CVC was positively correlated ($p<0.001$) with HTT final Trec and both post-HTT Trec and Tskin, whereas all HRV indices were negatively correlated ($p<0.001$) with HTT final Trec and both post-HTT Trec and Tskin.

CONCLUSION
In this study, HI individuals exhibited distinct CVC and HRV responses compared with HT individuals, during post-HTT measures. These differences indicate greater cutaneous vasodilation and reduced cardiac vagal modulation in HI participants following heat stress. The observed correlations with rectal and skin temperatures suggest that these alterations are primarily driven by the greater level of hyperthermia reached by HI individuals, which by definition characterizes heat intolerance. However, the absence of group differences at baseline indicates that resting cardiac autonomic activity and cutaneous vascular function are not inherently impaired in HI individuals.

MILITARY IMPACT
Heat intolerance has been shown to be associated with an increased risk of exertional heat stroke. The present findings suggest that this intolerance is not related to intrinsic impairments in cardiac autonomic regulation or cutaneous vasomotor control. Understanding these physiological responses may help to improve return to duty management in military personnel.

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Thematic 14 : Use of machine learning model for individal safety in High Intensity Conflicts

Le Grand Salon - Mod: B. Kingma + M. Buller

ORAL PRESENTATIONS

Enhanced Individualized Fatigue Prediction with Meta-Learning AI Models and Wearable Technology

Explainable Surrogate Models for Decision Support at Critical Thermoregulation Thresholds

Improving Ballistic Plate Fit Through 4D Body Scanning and Anthropometric Analysis

Towards Real-Time Human Thermoregulatory Digital Twins - Hybrid Modeling to Learn the Individual

POSTER PRESENTATIONS

Network Analysis of Text Data from Abstracts of Military Physical Performance Publications From 2000-2025

4D scanning for soldier and kit parameterization and fit

Thematic 14 :
Use of machine learning model for individal safety in High Intensity Conflicts

#47154785
Oral Presentation

Enhanced Individualized Fatigue Prediction with Meta-Learning AI Models and Wearable Technology

BACKGROUND
Sleep-centric fatigue poses a risk to operational readiness, especially in high-tempo military operations, leading to millions of dollars (USD) in accidental damage and loss of life. Therefore, the US Navy is developing the Command Readiness, Endurance, and Watchstanding (CREW) System, a wearables data capture and processing architecture that operates in a disconnected environment. Wearables measurements from this system can be used to predict fatigue with an ordinary differential equation (ODE) model (McCauley, 2013). However, the ODE model does not account for individual differences in circadian rhythms, sensitivity to sleep loss, or optimal sleep architecture, nor does it handle missing data. We developed and compared two AI models, one static and one few-shot meta-learner, with the aim of capturing individualized fatigue prediction from wearables data.

METHODS
Wearable data from Oura Gen3 including sleep stages, metabolic equivalents, heart rate, and heart rate variability were collected on US Navy sailors during in-port and underway demonstrations from 2020-2022, along with daily self-reports on fatigue as ground truth. A static "phenotype-informed" (SPI) neural network combined sailors' wearable data with demographics (age, sex, etc.) and sleep phenotype (PROMIS-Sleep Related Impairment instrument and recent self-reported total sleep time) to predict fatigue. A few-shot meta-learning (FSML) model was also developed, incorporating a global neural network encoder and few-shot learning (first two fatigue self-reports) for individualized prediction. Both models were prospectively validated on a 2025 shipboard CREW System demonstration with Oura Gen4 ring, using the area under the receiver-operating-characteristic (AUROC). The ODE model with wearable sleep inputs, augmented for missing data with last-observation-carried-forward (LOCF) sleep periods, was used as a benchmark.

RESULTS
Total model training data from sailors 2020-2022 amounted to N=5,197 surveys with wearable data from 737 unique subjects and N=575 surveys from 71 unique subjects used for model tuning/selection. The prospective shipboard validation provided N=1,675 surveys from 174 unique subjects. The FSML model outperformed all other models (AUROC 0.84), with the SPI model also performing significantly better (AUROC 0.74) than the augmented ODE model (AUROC 0.55). Further, the FSML model had enhanced dynamic tracking with changes in predicted fatigue correlating significantly to changes in ground-truth fatigue ($p = 0.05$ versus $p = 0.91$ for the SPI model).

CONCLUSION
Sleep-centric fatigue models leveraging wearable data have increased accuracy when accounting for individual differences rather than relying on global assumptions. Individual differences can be partly captured by static variables but are more effectively learned with few-shot meta-learning methods.

MILITARY IMPACT
These results suggest that future incorporation of a few-short meta-learning model into the CREW System will enable data-informed fatigue-based risk management to help improve operational readiness.

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Thematic 14 :
Use of machine learning model for individal safety in High Intensity Conflicts

#46717005
Oral Presentation

Explainable Surrogate Models for Decision Support at Critical Thermoregulation Thresholds

BACKGROUND
In operational settings thermoregulation models are used for decision support, but increasing complexity can reduce interpretability. This can limit trust and obscure which conditions drive risk. To address this gap, we introduce a workflow that converts complex physiology-based models into interpretable, threshold-focused surrogate models optimized for operational decision support, while preserving near-equivalent accuracy. This makes key risk drivers explicit and easy to communicate.

METHODS
We convert a heat-balance model into an interpretable three-level classifier (green, yellow, or red; "traffic-light" style) in five steps: (1) select a model, (2) define a decision threshold, (3) sample inputs across the validated range with dense sampling near the threshold, (4) fit an Explainable Boosting Machine (EBM; an interpretable additive model with limited interactions) to reproduce the model's decisions, and (5) prune the EBM to the simplest form that maintains performance. We demonstrate the approach on two international standards: ISO 7933 (Predicted Heat Strain, PHS) and ISO 11079 (Insulation Required, IREQ).

RESULTS
The EBM surrogates closely matched both standards: IREQ (9 inputs, AUC = 0.99; threshold 2 clo) and PHS (19 inputs, AUC = 0.98; threshold core temperature 39°C after 4 h steady work). We used these surrogates to produce traffic-light guidance: green/red for predictions below/above the decision threshold with ≥95% accuracy, and yellow for the boundary region. The surrogate models also quantify how each input shifts the prediction (via log-odds contributions), making the key drivers clear overall and for individual scenarios. Since log-odds are additive, they remain intuitively interpretable. Because the surrogates are simple additive models, they can be evaluated with simple arithmetic instead of specialized software, and are sufficiently fast for large-scale applications (e.g., gridded weather datasets).

CONCLUSION
This approach enables accurate, interpretable decision support from complex heat-balance models by learning transparent surrogates around a defined decision threshold (AUC ≥0.95 for both PHS and IREQ). It makes the key drivers of risk explicit for general guidance and for specific scenario assessments.

MILITARY IMPACT
Military decision support must be rapid, clear, and actionable. By converting complex heat-balance models into transparent surrogates, both the predicted risk category (relative to a defined threshold) and which factors drive risk (e.g., workload, clothing, and environment) are immediately clear. This supports targeted mitigation. The workflow is broadly applicable and can be adapted to many existing (thermoregulation) models.

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Thematic 14 :
Use of machine learning model for individal safety in High Intensity Conflicts

#46723040
Oral Presentation

Improving Ballistic Plate Fit Through 4D Body Scanning and Anthropometric Analysis

BACKGROUND
Body size, and shape have a significant effect on equipment fit. Canada, along with many countries, are seeking to adopt a wider range of plate sizes and cuts. Unfortunately, size guides used to fit ballistic armour are reliant on manual anthropometric measurements that are not reflective of individual body-shapes. Recent advancements in 4D scanning technology present an opportunity to improve full-body anthropometric measurement and plate sizing approaches. A use case for 4D scanning technology will be presented in three parts: 1) the use of machine learning (ML) to identify the anthropometrics most informative for selecting plate size; 2) the use of ML and 3D body scans to predict plate size; and 3) plate parameterization enabling the calculation of percent coverage.

METHODS
16 participants (9M; 7F) in the Canadian Armed Forces (CAF) were scanned using state-of-the-art 4D body scanning technology (MOVE4D, IBV, Spain). The MOVE4D system automatically computes 166 anthropometric measurements from homologous meshes. Participants were all sized (S, M, L, or XL) by experts familiar with the ballistic plates of the newly selected Canadian Dismounted Infantry Capability Enhancement (DICE) system. 1) Recursive feature selection (RFS) was performed using a random forest classifier (RFC) to rank anthropometrics in order of importance for ballistic plate size classification. 2) The torso was segmented from the full body 3D meshes and was used to train an RFC to predict plate size based on torso geometry. Model performance was evaluated using a leave-one-out cross validation approach where the F1 score was used to measure classification accuracy. 3) Principal component analysis (PCA) was then used to extract shape descriptors from 3D scans of the ballistic plates. Simple linear regression was used to learn how the plate descriptors change with size, enabling the generation of new plate sizes not included in the original dataset (i.e., XS and XXL). The surface area (SA) of the predicted plate size (±1 size) was then calculated relative to the SA of the torso, measuring the coverage provided by the DICE plates when sized appropriately.

RESULTS
After performing RFS, it was found that bust width, torso height, and waist girth were the most informative features for selecting plate size. The RFC predicted plate size with an accuracy >75%, with the model never predicting the plate size to be more than ±1 size from the ground truth. The trained regression model generated realistic meshes of plates ±1SD outside of the original size range (R2 = 0.995). When the SA of the interior surface of the plates were calculated relative to the SA of the torso, it was revealed that the ballistic chest and back plates cover 40-55% of the torso.

CONCLUSION
By combining 4D scanning technology with advanced analytical techniques, robust plate sizing guidelines can be established to ensure soldiers are provided with optimal protective armour. As the dataset grows, CAF-specific anthropometric recommendations can be provided regarding the most valuable anthropometric values for plate sizing. Next steps involve examining changes in 3D shape during dynamic tasks using the 4D scanner, to ensure that ballistic plates do not hinder movement.

MILITARY IMPACT
The result of this work are several tools that can be used to improve current equipment procurement procedures. Further, the developed ML models could enable large scale and fully automated sizing and virtual fit assessments; thus, improving plate fit.

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Thematic 14 :
Use of machine learning model for individal safety in High Intensity Conflicts

#46777064
Oral Presentation

Towards Real-Time Human Thermoregulatory Digital Twins - Hybrid Modeling to Learn the Individual

BACKGROUND
Predicting and optimizing warfighter performance is a critical goal of global militaries. Personnel must train and prepare in deployment-relevant environments, often in hot and humid conditions. Heat stressors are known to reduce exercise performance and increase the risk of exertional heat illness (EHI). Current wearable technology can provide some assessment of EHI risk but has limited ability to predict individual health state or future responses to additional training. This work aims to provide a basis for real-time physiological feedback, allowing for illness minimization and performance maximization via development of a physiological digital twin (DT).

METHODS
We utilized a hybrid modeling approach combining the strength of a physics/physiology-based human thermoregulatory model with a data driven approach. The SCENARIO (Sc.) model 1 was chosen for its lightweight framework suited to run on wearable devices. Sc. computes heat transfer to/from the body's core for given clothing and environments with an active cardiovascular/sweating system. Sc. was remastered using modern scaling factors and sex differences. Movement speed, heart rate (HR), skin temperature (Ts) and core temperature (Tc) from an approved ethics protocol were measured from 8 males and 4 females (22.6±3.2yrs, 67.7±8.5kg, 1.72±0.08m) who completed 2 timed (1 hour) (SET and SELF-paced) 5-mile movements on a treadmill in metabolic chamber at 22°C and 50%RH in a track suit (1.22CLO, 0.41Im). DTs for each individual were generated by 1) scaling the model for anthropometrics and sex; 2) learning 3 critical individual thermoregulatory model parameters connected to the active system (vascular skin conductance, vascular skin blood flow, and O2 extraction fraction) by minimizing the error between estimated and observed Tc, Ts, and HR; and 3) residuals were then minimized using a data driven approach (extreme gradient boosting combined with a local neural network). We compared the performance (MAE, Bias and SD) of the estimates of Tc, Ts, and HR of the DTs learned from the SET session to the original Sc. model for SELF session estimates using a paired t-test.

RESULTS
Tc, Ts, and HR estimates were significantly improved using the learned DTs for a more variable exercise session where Tc(°C): MAE 0.41 to 0.32*, bias −0.27 to −0.20, SD 0.38 to 0.31; Tsk(°C): MAE 1.39 to 0.83*, Bias 0.60 to −0.38*, SD 1.30 to 0.80* and HR(bpm): 14.0 to 11.7 bias −2.9 to −6.8, SD 15.5 to 11.3* for Sc. and DTs respectively (*p<0.05).

CONCLUSION
Utilizing hybrid modelling with a simple human thermoregulatory model in conjunction with data driven methods allowed us to learn accurate explainable human performance DTs. We were able to use those DTs to more accurately predict human physiological performance on a more variable exercise session. Our DTs show potential to estimate the underlying physiological state of the individual and to accurately predict future performance on new and novel tasks.

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Thematic 14 :
Use of machine learning model for individal safety in High Intensity Conflicts

#1000061
Poster Presentation

Network Analysis of Text Data from Abstracts of Military Physical Performance Publications From 2000-2025

BACKGROUND
Identifying performance themes in the literature can be challenging due to the vast amount of published work. Instead of a single performance thematic search (e.g., physical, psychological, or physiological), text analysis techniques can examine all these themes simultaneously. The purpose of this analysis was to examine changes in military abstract themes in performance-change-centered literature from 2000 to 2025 among active-duty military members.

METHODS
A Scopus literature search on military physical performance was conducted, yielding 1954 unique publications from 2000 to 2025. Rayyan, an artificial intelligence (AI) tool, was used screen each abstract, assign country, and conscript or volunteer labels. A corpus of 363 original investigations from 43 countries was included in this analysis. Bibliometric data used for this analysis included the year of publication, the abstract, and the country. Using RStudio (version 2026.01.0+392), the corpus was cleaned of English stop words and traditional academic terms, before being used for cluster analysis and semantic topic modeling. A Chi-square test was used to examine differences across the 6 most populus continents, and a 95% CI was used to assess differences between conscript and volunteer militaries. AI was used to help troubleshoot code in certain patches and was verified by a human to ensure credibility.

RESULTS
The top 3 countries with published literature were the United States (145), Finland (40), and the United Kingdom (24). From the abstract, the top 60 concepts formed 7 distinct clusters, with the term composition having the most connections (26). Eight distinct topics were evaluated across continents. These topics were cardiovascular and sleep stress (CSS), body composition and reproductive health (BCRH), musculoskeletal training responses (MTR), cognitive and deployment performance (CDP), recruit training and fitness standards (RTFS), load carriage biomechanics (LCB), injury risk and health behaviors (IRHB), and cadet and academy fitness training (CAFT). The proportions of each topic differed significantly ($\chi 2=88.85$, df=28, $p<0.001$) across continents. RTFS literature was dominant in Africa and Oceania, compared to MTR in Europe, LCB in Asia, and IRHB in the Americas. In a conscript-versus-volunteer analysis, only LCB differed between the two military types (0.31, 95% CI: 0.09-0.51) and was more dominant in volunteer militaries.

CONCLUSION
The results from this analysis of abstracts of manuscripts published between 2000-2025 show that themes differ worldwide. Bibliometric semantic clustering supported key hallmarks of military physical performance literature during topic modeling.

MILITARY IMPACT
Further work to assess these trends through a scoping review with a broader literature search and branch stratification should be conducted to identify important research priority areas from military literature of the first 25 years of the 21st century.

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Thematic 14 :
Use of machine learning model for individal safety in High Intensity Conflicts

#46722754
Poster Presentation

4D scanning for soldier and kit parameterization and fit

BACKGROUND

Differences in subjective equipment fit have been documented across soldiers of different sexes and statures. Understanding equipment fit is important for design and production, not only for overall comfort, but for the safety of the soldiers and their performance in field. The advancement of 4D scanning technology provides an opportunity to parameterize soldiers and kit configurations to understand how fit and coverage morph across different body shapes and sizes. To emphasize the applications of state-of-the-art 4D scanning technology for equipment fit in the military, we created military-specific morphable shape models incorporating load-carriage systems.

METHODS

16 participants (9 M; 7 F) were recruited from the Canadian Armed Forces (CAF). Participants were scanned in an A-pose using a 4D scanning system (MOVE4D, IBV, Spain), in three conditions: form-fitting clothing (slick), the current in-service (Clothe the Soldier; CTS), and the newly selected Dismounted Infantry Capability Enhancement (DICE) system fighting loads. The 3D participant meshes were aligned, and statistical shape models were developed for each condition. Principal Component Analysis (PCA) was used as a dimensionality reduction technique. Partial Least Squares (PLS) regression was then used to predict shape coefficients from a set of 166 anthropometric measurements computed using MOVE4D. A leave-one-out cross validation approach was used to evaluate model performance. To quantify the quality of the developed shape models, compactness, generality and specificity were measured. Compactness describes how well the shape model represents the shape variability. Generality measures the distance between the real and predicted shapes, to determine how well the model can represent shapes unseen during training. Specificity quantifies shape plausibility. The load-carriage systems were then isolated for each kit condition (CTS, DICE) and the surface area relative to the 3D bodies were computed, providing percent coverage.

RESULTS

Preliminary results revealed that for all shape models (Slick, CTS, and DICE), >90% of the variance was explained by the first three PC scores. The slick model had the best generality (RMSE <1.3 cm) and specificity (RMSE < 1.6 cm), indicating the shape models appropriately represent the body shapes included in the dataset. The CTS and DICE models both achieved a generality of < 2cm across the entire body (i.e., including extremities). These morphable models were then used to determine the full-body coverage of the CTS and DICE kits, with scores of 25% and 19% respectively.

CONCLUSION

4D scanning technology can be used to generate realistic shape models of CAF service members. These shape models enable the investigation of how equipment placement and coverage changes with body shape by morphing shapes along different anthropometric measurements. Next steps include, generating dynamic models allowing detailed investigations across time and through body deformation.

MILITARY IMPACT

Using these shape models combined with parameterized models of different military kits can help determine the trade-off between percent coverage and other performance metrics such as range of motion and speed. This presents the opportunity for virtual fit assessments across a diverse set of human shapes representative of the CAF. Moreover, shape models can help determine if certain body shapes are more susceptible to ballistic injury for various load-carriage systems.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

Salle Lucienne et André Blin - Mod: A. Sievert + M. Lovalekar

ORAL PRESENTATIONS

Stress fracture in the Royal Navy: can routinely collected organisational data help identify those at increased risk?

The Associations Between Mild Traumatic Brain Injury and Musculoskeletal Injury Among United States Service Members

Monitoring Health Problems in Military Personnel using the OSLO Sports Trauma Research Center Questionnaire on Health Problems

Using the capture-recapture method to estimate the incidence of musculoskeletal injuries during Marine Corps Officer Candidates School

The Impact of Battle Injuries, Disease, and Non-Battle Injuries on Military Readiness and Limited Duty Days in Deployed Military Personnel from 2003 to 2013

POSTER PRESENTATIONS

Sustaining Air Operations: Musculoskeletal Injury and Prolonged Care Among Military Pilots in High Intensity Conflicts

Development of Strategic Research Priorities for Addressing Musculoskeletal Injuries in the United States Military

Implementation of a musculoskeletal injury surveillance pilot in CANSOFCOM

Understanding the Musculoskeletal differences between Male and Female neck Anthropometry, Strength and Biomechanics

Activity recognition with a single body-fixed sensor in the Dutch military

The Injury Severity Paradox: A Single Metric to Evaluate Individual and Population Impacts

Incidence and Risk Factors for Musculoskeletal Injuries in British Army Trainees: Protocol for a prospective cohort study.

Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46576931
Oral Presentation

Stress fracture in the Royal Navy: can routinely collected organisational data help identify those at increased risk?

BACKGROUND
Stress fractures (SFs) are overuse musculoskeletal injuries that impact mobility and occur more frequently in military personnel than in the general population, disrupting occupational training and operational preparedness. We used routinely collected organisational data to identify characteristics associated with SF in Regular Royal Navy (RN) personnel and evaluated the predictive ability of these characteristics.

METHODS
We studied 63,442 Regular RN personnel (90.3% men) who served between 2013 and 2023. SFs were identified from Read codes. Baseline exposures included age, ethnicity, height, weight, body mass index (BMI), smoking status, trained status (untrained or trained), service (RN or Royal Marines [RM]), job role, rank, number of bodily systems medicated in the first year (as a marker of poorer baseline health), and (in women) progestogen contraceptive use. Some variables were incomplete or not concurrent with service entry. Associations with incident SF were examined using sex-stratified univariate and multivariable Cox regression.

RESULTS
Median (lower quartile, upper quartile) baseline age was 25 years in both men (21, 32) and women (21, 30). SF incidence was 1.3% in men and 1.7% in women. In men, RM service was the strongest individual predictor (hazard ratio 8.55, 95% CI 7.25–10.07 versus RN; Harrell's C 0.75), followed by ≥1 medicated system (3.32, 2.42–4.55 versus <1); higher BMI was protective (0.86, 0.84-0.88). In women, trained status (0.11, 0.05–0.24 versus untrained) and higher BMI (0.86, 0.80-0.91) were protective, while ≥1 medicated system increased risk (7.15, 4.67–10.95). Most individual predictors showed modest discrimination (C≈0.60) but multivariable models, including univariate-significant variables, showed good discrimination (0.85 in men; 0.81 in women).

CONCLUSION
Consistent SF risk factors were BMI, trained status and poorer health. As all personnel are pre-assessed against service entry medical and fitness standards, higher BMI values may reflect healthier (muscle- vs. fat-mass) body composition rather than obesity. Given this pre-assessment—as well as age-distribution of this workforce and limitations to data completeness and timeliness—BMI associations should be interpreted cautiously. Improving consistency and quality of service entry and through-career data may improve injury surveillance and prevention.

MILITARY IMPACT
Stress fractures hamper operational preparedness and continuity of service military populations. This study of Regular RN personnel indicates that routinely collected data can identify population-level patterns of SF risk, but poor data quality and incomplete capture require cautious interpretation. The primary military relevance of these findings lies in demonstrating the potential of organisational data to support injury surveillance and inform prevention strategies contingent on improvements in data completeness, timing, and integration across service pathways.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46685104
Oral Presentation

The Associations Between Mild Traumatic Brain Injury and Musculoskeletal Injury Among United States Service Members

BACKGROUND
It has been shown in athlete populations that mild traumatic brain injury (mTBI) is associated with higher musculoskeletal injury (MSKI) risk, and, to a lesser extent, that MSKI is associated with higher mTBI risk. However, there is limited research on these associations in military populations. This epidemiological study used injury and extended follow-up data from a large cohort of US service members (SMs).

METHODS
This study sampled medical record data from over 750,000 US SMs (Air Force, Army, Marine Corps, and Navy) who enlisted between 2016 and 2020 and were followed through 2023. Two separate propensity score-matched study samples were constructed for each injury analysis. Injuries were identified using International Classification of Diseases, 10th Revision codes defined by the Armed Forces Health Surveillance Division. Incident MSKI or mTBI events were identified as the first event at least 1 month following the initial mTBI or MSKI incident, respectively. Conditional multivariable logistic regression models were used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for associations between initial and subsequent injury. All models were adjusted for demographic and military-relevant characteristics.

RESULTS
For MSKI risk following mTBI, the propensity score-matched cohort sample included 26,784 SMs (mean age at entry = 20 ± 3 years; 17% female; 59% White; mTBI cases = 13,292, MSKI = 14,330). For mTBI risk following MSKI, the propensity score-matched case-control sample included 33,748 SMs (mean age at entry = 20 ± 3 years; 21% female; 56% White; MSKI = 26,722, mTBI cases = 16,874). Our multivariable association analysis showed that mTBI was associated with more than two times (OR = 2.22; 95% CI 2.10-2.35) higher odds of subsequent MSKI, relative to no mTBI. In the matched case-control sample, MSKI was associated with 54% (OR = 1.54, 95% CI 1.46-1.63) higher odds of subsequent mTBI compared with no MSKI.

CONCLUSION
In this large sample of US SMs, an initial mTBI or MSKI injury was associated with higher odds of subsequent MSKI or mTBI injury, respectively. Findings suggest the importance of providing enough time and training for rehabilitation following injury and understanding of factors contributing to subsequent injury risk. This presentation will also outline the initial development efforts of a data dashboard to be used as a clinical tool for describing injury risk estimates.

MILITARY IMPACT
This research reveals a cyclical link between mTBI and MSKI. This reciprocal risk means that an initial injury, of either type, significantly increases the probability of a second, different injury, potentially leading to a cascade of medical issues. This directly impacts the military by reducing mission readiness, increasing medical costs and attrition, and compromising warfighter lethality. The findings underscore the need for improved post-injury protocols. Simply treating the initial injury is not enough. Military leaders and clinicians must ensure that SMs are afforded sufficient time and receive comprehensive, evidence-based rehabilitation to prevent a secondary injury.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46740067
Oral Presentation

Monitoring Health Problems in Military Personnel using the OSLO Sports Trauma Research Center Questionnaire on Health Problems

BACKGROUND
Military personnel face diverse, intense, and often unchangeable occupational demands, resulting in a high prevalence and burden of health problems. Traditional health registration methods capture health problems only when they result in limited duty status, often delaying timely intervention. Therefore, this study investigated the relationship between occupational tasks and the emergence of health problems at the Royal Netherlands Marechaussee (RNLM) using the Oslo Trauma Research Centre Questionnaire on health problems (OSTRC-H2). /

METHODS
This was a 12-week prospective observational cohort study in the operational branch of the RNLM. All ±6500 RNLM employees were eligible to participate. Participants used the Perfyso™ app to register their health status and occupational tasks weekly. We used linear mixed model analyses to estimate the relationship between occupational tasks and the occurrence of health problems.

RESULTS
346 participants registered, and 293 completed the first-week questionnaire, with a mean weekly response rate of 51% (95% CI 40–61%). Participants reported a total of 224 health problems, with a mean weekly prevalence of 23% (for all health problems) and 5% for substantial health problems. Most reported health problems were illnesses (43%), followed by physical health problems (35%) and mental health problems (22%). We found that dynamic and operationally demanding tasks, such as Border Policing – Mobile Security Surveillance and Security and Surveillance – Subjects, were associated with a higher risk of health problems than less demanding tasks like managing or deskwork.

CONCLUSION
This study found that dynamic and operationally demanding tasks were associated with a higher risk of health problems than less demanding tasks. Our findings indicate that this tool is a viable option for capturing health problems before they result in dropout in a military population.

MILITARY IMPACT
The OSTRC-H2 can capture health problems before they lead to dropout or limited-duty status, which is essential for sustaining military readiness.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46785819
Oral Presentation

Using the capture-recapture method to estimate the incidence of musculoskeletal injuries during Marine Corps Officer Candidates School

BACKGROUND
Studies of the epidemiology of musculoskeletal injuries (MSIs) in military populations typically utilize a single source of data, either medical chart review or self-reported. Medical chart reviewed data may be incomplete if participants do not seek medical care, which is especially problematic in military populations. Self-reported MSI data may be incomplete due to recall issues, especially for less severe MSIs. The purpose of this analysis was to combine medical chart reviewed and self-reported data using the capture-recapture method to estimate the ascertainment-corrected cumulative incidence of MSIs during a 10-week Marine Corps Officer Candidates School training course.

METHODS
Medical chart reviewed MSI data were collected for Officer Candidates who sought medical care, from internal reports of the Officer Candidates School physical therapy department. Self-reported MSI data was collected using a customized survey administered at the end of the training period. A two-source capture-recapture analysis was conducted using the Chapman modification of the Lincoln- Petersen estimator, to assess the completeness of MSI data and to estimate the ascertainment-corrected 10-week MSI cumulative incidence.

RESULTS
MSI data were available for 549 participants (age: 25.0±3.1 years, sex: males 84.2%). A total of 126 participants were identified as injured in the medical chart review (medical chart review 10-week cumulative incidence: 126/549 = 23.0%), and 313 participants were identified as injured in the self-reports (self-report 10-week cumulative incidence = 313/549 = 57.0%). The capture-recapture estimate of the 10-week cumulative incidence was 65.9% (95% confidence interval: 62.2%, 69.5%). The overall, medical chart review, and self-report ascertainment percentages were 91.3%, 34.9%, and 86.6%, respectively. When various MSI types were analyzed separately, overall ascertainment varied by MSI type. The overall ascertainment was highest for sprains (79.6%) and lowest for pain/spasm/ache (32.9%).

CONCLUSION
The overall ascertainment using two sources of MSI data was good, but medical chart review ascertainment was low. This may be due to the tendency to not seek medical care for MSIs in military trainee populations. There is a need for further investigation of the application of the capture-recapture method to MSI data in various military populations and assessment of the relative benefits of MSI data from different sources is needed.

MILITARY IMPACT
Injury epidemiology studies in military populations that use a single source of data may lead to underestimation of the true burden of musculoskeletal injuries. Further investigation into the application of the capture-recapture technique to adjust for under-reporting and to understand the complete burden of injuries is needed.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#47143617
Oral Presentation

The Impact of Battle Injuries, Disease, and Non-Battle Injuries on Military Readiness and Limited Duty Days in Deployed Military Personnel from 2003 to 2013

BACKGROUND

Disease and non-battle injuries (DNBI) have a large impact on force readiness and cause more lost manpower compared to battle injuries (BI). The most common non-battle injuries (NBIs) are musculoskeletal injuries (MSKI), often caused by sports, physical training, slipping and falling, or motor vehicle accidents, and mental health (MH) conditions, such as stress, anxiety, sleep disorders, and depression. Additionally, Warfighters can be exposed to diseases specific to a region (e.g., malaria or dengue fever), skin irritations (e.g., dermatitis or heat rash), or infection (e.g., influenza or E. coli). To maintain force readiness in future combat operations, limiting DNBI and enhancing return to duty (RTD) in Warfighters after BI and DNBI will be imperative for mission success. For combat operations in Iraq and Afghanistan, there has been a significant amount of research that quantifies incidence rates, causes and evacuation rates of DNBI, but there has been limited data presented on lost or limited duty days. The purpose of this study is to characterize the type of BI and DNBI and examine the total number of limited duty days during deployments.

DATA & METHODS

Data in this study analyzed medical encounters (N=4,200,321) from fiscal years 2003-2013 that were documented in the Theater Medical Data Store (TMDS) and the Department of Defense Trauma Registry (DoDTR). The data were extracted and retrospectively analyzed from the Soldier Performance, Health, and Readiness Database (SPHERE), managed by the U.S. Army Research Institute of Environmental Medicine (USARIEM). First, the top BI and DNBI medical encounters were characterized along with the resulting outcomes (RTD, limited duty, confined to quarters, medical evacuation, and death from injury). Second, the total number of limited duty days were estimated from the most common BI and DNBI. RESULTS: 83.7% of all the medical encounters in a deployed setting between 2003-2013 were classified as DNBI, 5.0% were BI, and 12.3% were unknown.

The top BI encounters included musculoskeletal injuries (N=46,374), MH conditions (N=26,706), firearm or explosion injury (N=22.071), and concussion or non-fracture intracranial injury (N=19,120). The top DNBI included musculoskeletal injuries (N=806,437), MH conditions (N=282,342), respiratory infections and disease (N=227,418), and sleep disorders (N=73,574). Encounters for DNBI typically had higher rates of returning-to-duty than BI (77.4% vs 41.6%) and a low rate of evacuation (2.2% vs 30.0%). Warfighters spent over 3 million days on limited duty for musculoskeletal injuries, 287,000 days for mental health conditions, nearly 630,000 days for skin disease, nearly 200,000 days for respiratory infections and disease, and 150,000 days for abdominal and pelvic injuries. For BI, Warfighters spent over 60,000 days on limited duty from musculoskeletal injuries, 49,000 days for mental health conditions, 25,000 days for concussions or intercranial injuries, and 20,500 from headaches/migraines.

CONCLUSION

Mission success depends on Warfighter availability. Preparing for BI and DNBI in future conflicts presents challenges to ensure that Warfighters are healthy and mission ready While all combat operations are unique, leveraging medical encounter data, outcomes from medical encounters, and limited duty days from recent conflicts, can be used by decision makers to aid in resource allocation in future conflicts, including medical supplies and medical providers. The views expressed in this Abstract reflect the results of research conducted by the author(s) and do not necessarily reflect the official policy or position of the U.S. Army, Department of War, nor the U.S. Government.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46707262
Poster Presentation

Sustaining Air Operations: Musculoskeletal Injury and Prolonged Care Among Military Pilots in High Intensity Conflicts

BACKGROUND

Air superiority is essential for mission success in high intensity conflicts. In resource-constrained environments, delayed evacuation can necessitate prolonged casualty care. Military pilots, exposed to intense G-forces, immobility, and repetitive movements, are at increased risk for musculoskeletal injuries (MSKi) that threaten operational readiness. Recovery times are especially critical when rapid redeployment is required and medical support is limited. Analyzing MSKi patterns and aircraft-specific injury prevalence enables targeted strategies to optimize pilot resilience and sustain air operations. By combining all pilots in the analysis, this study reflects operational realities where pilots are deployed as a unified force. This approach ensures findings are directly applicable to the collective demands faced during high intensity conflict and supports actionable strategies for optimizing pilot resilience and sustaining air operations. The aim is to identify aircraft-specific flight-related MSKi in military pilots during high intensity conflict, comparing findings with non-pilot controls.

METHODS

This retrospective cohort study used Defense Medical Surveillance System data to examine ambulatory MSKi health care encounters among active component U.S. Armed Forces members from 2016 to 2024. The pilot cohort (N=53797) included all fixed-wing fighter, bomber, support, helicopter, and unmanned aerial vehicle pilots. Analyses assessed MSKi prevalence and the variation in injury types across aircraft categories using logistic regression. Pilots were compared with non-pilot controls (officers and warrant officers in non-pilot or maintenance roles, N=44626).

RESULTS

The six most prevalent musculoskeletal (MSKi) conditions among military pilots were low back pain, knee pain, shoulder pain, cervicalgia (neck pain), ankle and foot joint pain, and hip pain. Aircraft type was a major source of variation: fighter pilots experienced the highest rates of cervicalgia (32%), while helicopter pilots had elevated prevalence across multiple conditions, notably back pain (27%). Compared with non-pilots, pilots had lower odds of low back pain (OR = 0.73, 95% CI: 0.71–0.75), knee pain (OR = 0.65, 95% CI: 0.63–0.67), shoulder pain (OR = 0.78, 95% CI: 0.76–0.80), ankle/foot pain (OR = 0.62, 95% CI: 0.59–0.65), and hip pain (OR = 0.60, 95% CI: 0.57–0.63). In contrast, pilots had higher odds of cervicalgia compared to non-pilots (OR = 1.07, 95% CI: 1.04–1.10). Non-pilots exhibited higher prevalence rates for most MSKi conditions than pilots, though prevalence patterns varied by aircraft type.

CONCLUSION

These findings demonstrate clear aircraft-specific patterns of musculoskeletal injury (MSKi) among military pilots, with significant variation in neck and back pain. Pilots overall exhibited a lower prevalence of health care encounters for MSKi compared to non-pilots, except for cervicalgia, which was more prevalent in aviation roles. This underscores the unique physical demands of different aircraft environments and their influence on musculoskeletal health.

MILITARY IMPACT

The identification of aircraft-specific MSKi patterns, particularly the increased incidence of cervicalgia in pilots, reveals actionable opportunities for targeted prevention strategies. Implementing such measures can enhance aircrew health and help maintain operational readiness during high intensity conflict scenarios.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46658925
Poster Presentation

Development of Strategic Research Priorities for Addressing Musculoskeletal Injuries in the United States Military

BACKGROUND
Musculoskeletal injuries (MSKI) are the single greatest threat to the readiness of the force. In addition to affecting operational readiness, they also impact training continuity, duty performance, and long-term health outcomes.With over 50% of Service members sustaining a new MSKI each year, the overall burden contributes to millions of limited duty days, high healthcare costs, and “non-deployable” status. In response to these challenges, the Defense Health Agency developed the Strategic Research Plan (SRP) for MSKI to establish a coherent research agenda to address science and technology priorities across the continuum of care.

METHODS
Over 40 United States Department of War stakeholders and subject matter experts from across the services and Department of Veteran’s Affairs were invited to participate in the development of the SRP prioritization. Participants included, but were not limited to, stakeholders in clinical care, program and portfolio manager, acquisitions experts, advanced development experts, and senior leaders. Capability Requirements were prioritized based on rankings and weights from the Analytical Hierarchical Process. The existence and extent of deficiencies in the current state of research determined through the Research Landscape Analysis. Lastly, down-selection occurred such that only capabilities deemed feasible to complete and that could realistically address deficiencies in the current science and technology landscape were included.

RESULTS
The prioritized musculoskeletal injury capability requirements were organized into 6 separate areas: 1. Assessment and Diagnosis of MSKI – diagnostic decision support tools for MSKI, 2. MSKI Risk Mitigation – countermeasures to mitigate primary MSKI risk factors in Service members, 3. Initial Care for MSKI – initial MSKI treatment strategies, technologies, and techniques to mitigate sequelae and optimize Service member outcomes in garrison and forward deployed settings, 4. Regenerative Medicine for MSKI – regenerative medicine approaches to augment MSKI care and treatment to optimize Service member outcomes, 5. Rehabilitative Care for MSKI – rehabilitative care to mitigate sequelae and optimize service members outcomes, 6. Return-to-Duty and Reintegration- return-to-duty screening and decision support tools to optimize military unit reintegration. A total of 54 separate capabilities were identified within the six areas to advocate for a synergistic research approach that bridges basic science to translational research, and then through clinical investigation.

CONCLUSION AND MILITARY IMPACT
The resulting MSKI SRP outlines the targeted science and technology investments that can address the multifactorial nature of MSKI, as well as the strategies to reduce the incidence, improve outcomes, and sustain Service member readiness across the force. It also offers a roadmap for future research partnerships and innovations that can transform military musculoskeletal health.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46663499
Poster Presentation

Implementation of a musculoskeletal injury surveillance pilot in CANSOFCOM

BACKGROUND
Musculoskeletal injuries (MSKI) present a substantial operational and clinical challenge within military organizations. For CANSOFCOM, a consistent and reliable method of capturing MSKI data has been needed to better understand injury patterns and epidemiology, healthcare utilization, and readiness implications. To address this gap, a digital MSKI surveillance system was developed and piloted to determine its feasibility for integrating standardized injury reporting into routine clinical practice.

METHODS
The system was implemented within CANSOFCOM, using secure digital tablets to collect both member- and clinician-reported MSKI information. System feasibility was assessed by monitoring usage patterns, system function, workflow integration, and the reliability of data transfer to a secure backend environment. Feedback from healthcare providers and leadership supplemented quantitative metrics to provide a comprehensive understanding of system adoption. The system works in a complimentary fashion to existing traditional electronic medical records by collecting an expanded set of contextual information surrounding MSKI within CANSOFCOM.

RESULTS
The surveillance system was successfully integrated into the clinical environment and has operated continuously since initial deployment, with only brief periods of planned or incidental downtime. Data entry processes were adopted by both members and healthcare providers with varying degrees of success, while the digital workflow transitioned smoothly into protected backend IT systems. Personal information was securely managed, and automated data flows supported the creation of visualization dashboards to translate injury information for leadership and clinical teams. These processes demonstrated the system's functional reliability, its suitability for routine use, and its potential for expanding injury related situational awareness across the unit.

CONCLUSION
The pilot demonstrated that digital MSKI surveillance can be effectively implemented within CANSOFCOM health services, to supplement existing systems. This pilot has proven feasible, secure, and capable of capturing meaningful injury related information while integrating into established clinical workflows. Continued improvements in uptake and data completeness are expected to further enhance the system's utility for understanding MSKI trends and resource demands.

MILITARY IMPACT
A functional MSKI surveillance system strengthens military readiness by enabling more informed decisions on rehabilitation needs, clinical resource allocation, and injury prevention strategies. The system provides a scalable, digitally driven framework adaptable to varied military contexts, supporting commanders and health services personnel in maintaining operational capability through timely, actionable MSKI insights.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46695823
Poster Presentation

Understanding the Musculoskeletal differences between male and female neck anthropometry, strenght and biomechanics

BACKGROUND

Neck pain is commonly reported by military aircrew and is influenced by several factors including wearing head-borne mass, posture and +Gz acceleration. Female aircrew report a higher rate of neck pain compared to males, despite females accounting for ~5% of UK military aircrew. Any potential difference in neck pain/musculoskeletal injury (MSI) risk between sexes emphasises the need to better understand the aetiology of MSI on the female neck. Currently, when informing neck MSI risk, female aircrew are generally assumed as small-scaled male equivalents but the appropriateness of this assumption has not been properly investigated. Previous research that has demonstrated sex differences in neck morphology have not accounted for sex differences in neck anthropometry. A better understanding of sex differences in neck anthropometry, biomechanics and strength is an important step in the understanding of whether MSI risk is different in female and male aircrew.

METHODS

This study received favourable ethical opinion from the Ministry Of Defence Research Ethics Committee. Anthropometric measurements and data relating to multi-directional neck Range of Motion (RoM), maximal neck external force (extension, flexion, left and right lateral flexion), and neck flexor and extensor muscular endurance were collected. Statistical analyses of the data were carried out using generalised linear modelling with stepwise reduction in predictor variables to derive a 'best-fit' model.

RESULTS

Data were collected from 80 participants (38 females, 19-62 years; 42 males, 22-64 years). Males had larger head and neck anthropometry (all measures) than females.No statistical differences were found between female and male neck RoM. RoM did not correlate with anthropometry measures. However, increasing age was shown to decrease neck RoM.Before accounting for anthropometric/demographic factors, males exerted 1.8-2.3x greater neck force than females. After accounting for measured anthropometric/demographic factors, males exerted 1.4-1.8x greater neck force than females. Regardless of sex:• increasing neck circumference by 1 cm increased estimated exerted force for extension (11%) and lateral flexion (5%); • flexion and extension exerted force was 1% lower if a person was 1 year older than another. Before accounting for anthropometric/demographic factors, a significant sex difference was found in muscular endurance for the neck extensors (females: 174s, males: 313s) and neck flexors (females: 88s, males: 148s). However, after accounting for measured anthropometric/demographic factors, there was no effect of sex on endurance times. Regardless of sex, increasing neck width by 1 cm resulted in increased neck flexor endurance (30%) and extensor endurance (46%). Older participants had higher endurance times; a participant 1 year older had an increased endurance time by 1%.

CONCLUSION

Females should not be regarded as small-scaled male equivalents as differences were found in neck strength after accounting for larger anthropometry in males. Regardless of sex, neck width was the most suitable anthropometric measure associated with improved neck muscular performance and could be used to monitor aircrew neck health.

MILITARY IMPACT

The findings from this research should be explored by those involved in aircrew conditioning programmes and those treating aircrew, to understand whether any practicable changes/interventions could be implemented on a population specific basis (sex, age anthropometry groups etc.).

AUTHORS

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46740200
Poster Presentation

Activity recognition with a single body-fixed sensor in the Dutch military

BACKGROUND
Musculoskeletal injuries are among the leading causes of dropouts from military training and operational duty, resulting in significant financial costs and reduced operational readiness for military organisations. Monitoring physical load during training and operational tasks has the potential to reduce this musculoskeletal injury burden. Accelerometry can objectively assess human physical activity by providing estimates of an activity's duration, frequency, and intensity. Therefore, this study aims to classify the most relevant military police activities using a single body-fixed tri-axial accelerometer in a practical setting.

METHODS
Twenty-three participants performed a protocol of relevant military police activities while wearing a single body-fixed tri-axial accelerometer and a heart rate monitor. For reference, all activities were recorded with a video camera and manually labelled by one researcher. We created two sets of labels: a detailed set that incorporated all relevant activities (sprinting in a straight line, sprinting in a zigzag) and a lean set that used broader labels (i.e. sprinting). We extracted key components using principal component analysis and used those to train a random forest classifier. We internally validated the model using the leave-one-subject-out method to create a confusion matrix for both label sets against the reference method, including their accuracies.

RESULTS
The lean label set was predicted with 82.8% accuracy, indicating a moderate-to-strong classifier. The detailed label set was predicted with 63.2% accuracy, indicating a weak classifier due to misclassifications of short, non-repetitive activities. The analysis further revealed that heart rate was a non-distinguishing feature in activity recognition across all activities.

CONCLUSION
The algorithm developed in this study accurately predicted continuous, repetitive activities, but not short, non-repetitive activities. The results of this study go beyond previous reports, showing that the classification model of the lean label set could classify carrying, crawling, and digging in a military setting with moderate accuracy. Future studies may incorporate multiple sensors and more features to better distinguish between short, non-repetitive activities.

MILITARY IMPACT
Effective load management requires accurate, objective monitoring of soldiers' activities during operational duties. A single body-mounted accelerometer may offer a practical and feasible solution for objectively quantifying physical activity in the field.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46766020
Poster Presentation

The Injury Severity Paradox: A Single Metric to Evaluate Individual and Population Impacts

BACKGROUND
Injuries are the leading cause of medical non-readiness across U.S. Military Services resulting in more than 25 million medical provider-prescribed limited duty days (LDD) annually. Traditional injury severity scales are designed to triage patients with acute traumatic injuries in emergency settings and are not practical for the vast majority of injuries that are non-life threatening. Overuse injuries due to cumulative microtrauma (CMT) were a leading reason for medical evacuations from theaters of operation in Operation Iraqi Freedom and Operation Enduring Freedom.

METHODS
Three years (2019-2021) of U.S. Active Component Army data obtained from the Electronic Profile (e-Profile) Module within the U.S. Army Medical Protection System (MEDPROS) were verified against Soldiers' medical record data obtained from the Military Health System Data Repository. Verified injury profiles were categorized according to the Defense Centers for Public Health-Aberdeen, Injury Prevention Branch Injury Taxonomy. Heat maps were created for Soldiers in the 90th percentile and below. Injury impact on Service medical readiness was depicted by summing LDD by body part and injury type using a four-color scale: blue (1-49,999 days); green (50,000-199,999); yellow (200,000-499,999); red (≥500,000).A heat map estimating median LDD values by body part and injury type was used to visualize the impact of injuries on duty limitations of individual Soldiers; blue (1-18 days); green (19-36); yellow (37-54); orange (55-72); red (>72).

RESULTS
Over three years, 300,000 Soldiers were prescribed 27.6 million injury-related LDD. For Soldiers with injury profiles, the mean age=28.2 yr; median age=26 yr; standard deviation=7.6. The 270,911 Soldiers with temporary profile durations up to 90th percentile accounted for a total of 14,722,574 LDD; mean=54.3 LDD; median=34 LDD. On the heat map depicting injury impact on the Soldier population, the most frequent injury types were overuse due to CMT, mainly musculoskeletal tissue damage, accounting for 8,199,369 LDD among 171,110 Soldiers (63.2%). This was followed by acute traumatic injuries, sprain/joint damage with 2,460,592 LDD affecting 31,696 Soldiers (11.7%) and fracture, with 1,388,409 LDDs affecting 18,425 Soldiers (6.8%). On the heat map depicting impact of injury to individual Soldiers, the 'warmest' injury types as measured by median LDD, were fracture of the knee or ankle (98 LDD); fracture of the hip (94 LDD); followed by fractures of the middle back, upper arm, and shoulder all with 91 LDD. Warmest median LDD values for the shoulder, hip, and knee were also observed for other acute traumatic injury types such as sprain/joint damage, strain tear, and dislocation.

CONCLUSION
CMT injuries had the largest impact on this military population as measured by total LDDs due to temporary medical profiles, whereas acute traumatic injuries had the greatest impact on individual Soldiers as indicated by the median LDDs per Soldier.

MILITARY IMPACT
Summarizing LDDs provides an opportunity for military leaders to evaluate injury impacts on individuals versus the population using an easy-to-understand metric. Measuring injury severity in LDDs is less subjective than trauma scales, and more appropriate for most military populations. Expanding leaders' understanding of how injury severity manifests differently in populations vs. individuals can have a profound influence on injury prevention efforts and medical readiness prioritization.

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Thematic 15 : Epidemiology of musculoskeletal injuries in military settings

#46802435
Poster Presentation

Incidence and Risk Factors for Musculoskeletal Injuries in British Army Trainees: Protocol for a prospective cohort study.

BACKGROUND
Musculoskeletal injuries (MSKIs) are the single greatest health and operational threat presently faced by the British Army recruit population, resulting in lost training time, lower mood state, chronic morbidity and permanent discharge. This large prospective cohort study will use advanced tools and technologies to identify novel, independent, and modifiable risk factors for MSKI during initial training. It will describe injury epidemiology and develop statistical models to predict individuals or groups at risk, informing future interventions to reduce MSKI incidence and burden.

METHODS
British Army trainees will be recruited during the first week of initial training across four training sites. Participants will attend a satellite laboratory to complete a baseline screening session, comprising of four components: (i) questionnaires, (ii) anthropometry, (iii) blood analysis, and (iv) biomechanical assessment. The questionnaires include demographic information, female-specific health questions and growth and maturation status. A previously validated military pre-training questionnaire (British Army population) will assess injury history, prior physical activity, diet, alcohol consumption, and nicotine use. Sleep quality will be evaluated using the Pittsburgh Sleep Quality Index. Psychological wellbeing will be assessed using validated scales measuring perceived stress, anxiety, depression, and general wellbeing. Anthropometric assessments will include height, body mass, waist and calf circumference, and body fat percentage estimated from skinfold measurements at four sites. Fingertip capillary blood samples will be collected to quantify vitamin D2 and D3, folate (vitamin B9), vitamin B12, and iron concentrations. Biomechanical assessment will include three domains. First, kinematic gait data will be collected using a markerless motion-capture system (ReCapture) with four high-definition cameras during treadmill walking, running, and vertical jumping. Second, tibial accelerations will be recorded simultaneously using wearable inertial sensors. Third, plantar pressure will be measured using a 2 m pressure plate during static stance and barefoot walking and running trials along a 12 m runway. Dynamic postural stability will be assessed using force plate–derived ground reaction forces during single-leg landings from anterior–posterior and medial–lateral jump tasks. Physical fitness, training exposure, and MSKI outcomes will be monitored throughout basic training (BT) and for six months after training completion. These data will inform development of a multivariable injury prediction model. The target sample size is approximately 4,000 trainees recruited over two years.

MILITARY IMPACT
This large prospective cohort study will help Defence identify independent risk factors for MSKI in British Army trainees using best-available methods. The MSKI Prevention Programme will enhance health and performance, reduce injury risk, and support duty of care through population-specific data models that enable targeted, person-centred interventions before and during training. Lower MSKI rates should improve first-time pass rates and trainee throughput, while reducing long-term injury risk across soldiers' careers, strengthening long-term operational readiness and workforce sustainability.

AUTHORS

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Thematic 16 : Physiology in cold environments Part II

Salle Moebius - Mod: C. Bourrilhon + R. Kolegard

ORAL PRESENTATIONS

Impact of acute caffeine intake on local tolerance to cold before and after total sleep deprivation

Physiological and Performance Consequences of Severe Energy Deficit During Prolonged Cold-Weather Military Ski Patrolling

A novel simulation and analysis technology for the study of local responses to cold. A case control study.

Attention Control Changes During a Long Range Patrol Operation on Land-Over-Snow-Vehicles in Canadian High Arctic: A Preliminary Study

POSTER PRESENTATIONS

Exosomes Derived from Human Stem Cells Acts as Early Stabilizer to Ameliorate Symptoms of Cold Stress in Mouse Model

Influence of Tyrosine Supplementation on Cognition and Physiology during Outdoor Cold Stress

Metabolic and Stress-Related Hormone Changes Between Seasons During Cold Weather Military Training

Chronic Polyphenol Supplementation Effects on Physiological and Cognitive Responses to Cold Water Immersion

Salivary DNA Methylation Biomarkers for Predicting Frostbite Susceptibility Prior to Arctic Deployment

Study of sleep in cold environments during a 3-week military winter raid in autonomy

Caffeine Supplementation to Reduce Physical and Cognitive Fatigue in Soldiers Operating in Hypoxic and Cold Environments : a Pilot Field Study

Single Nucleotide Polymorphisms in FADS2, LRP5, and PRKG1 are Associated with Frostbite Susceptibility in Military Personnel Deployed to Arctic Regions

A 24-hour cold exposure simulation in humans: peripheral blood transcriptomics reveal stable gene expression with selective immunometabolic regulation

High Altitude High Open (HAHO) parachuting : case report of a face frostbite

Thematic 16 : Physiology in cold environments Part II

#45920952
Oral Presentation

Impact of acute caffeine intake on local tolerance to cold before and after total sleep deprivation

Total sleep deprivation (TSD) alters local cold tolerance and could thus increase the risk of cold injury. We evaluated the impact of acute caffeine intake, the main countermeasure to TSD-related deleterious effects, on local cold tolerance before and after TSD.

Thirty-six healthy subjects underwent two TSD protocols (i.e., continuous wakefulness), with randomized crossover intake of acute caffeine or placebo (2.5 mg/kg) administered twice during wakefulness. Before and after 33 h of TSD, finger (index and annular) temperature and skin blood flow were assessed during cold-water immersion (CWI, 5 ◦ C, 20 min) followed by 20min of rewarming in ambient air.

We showed no significant effects of TSD on mean finger temperature during CWI in the placebo condition, but a significant reduction of the minimal temperature (8.86 ◦ C ± 0.35 ◦ C vs. 8.64 ◦ C ± 0.27 ◦ C, p = 0.02). During rewarming, we showed a reduction in temperature in the placebo condition (p = 0.02 for the mean temperature and p = 0.03 for the maximal) and an increase in the skin blood flow disparity between fingers at the four points of laser speckle rewarming measurements (p = 0.03). After TSD, acute caffeine intake (vs. placebo) increased mean (+2.11 ◦ C ± 0.21 ◦ C, p = 0.01) and minimal (+0.61 ◦ C ± 0.10 ◦ C, p = 0.02) finger temperatures during CWI, and improved rewarming after CWI (mean andmaximal temperatures) (+2.28 ◦ C ± 0.08 ◦ C, p = 0.01, and +2.06 ◦ C ± 0.12 ◦ C, p = 0.02, respectively). Before TSD, acute caffeine intake significantly increased (vs. placebo) mean temperatures during CWI (p = 0.03) and reduced pain from the onset (p = 0.03) to the end of CWI (p = 0.02) and the first 2min of rewarming (p = 0.04). There was also a significant main effect of habitual daily caffeine consumption on minimal finger temperatures during CWI, which decreased significantly between 0 and 600 mg consumption (R2 =−0.43, p = 0.01), independently of the effects of day (before and after TSD) and treatment (caffeine and placebo conditions).

These findings suggest that acute caffeine intake could be a protective countermeasure to local cold tolerance, particularly during TSD. However, habitual daily caffeine consumption is a factor of individual variability that should be recorded during CWI protocols.

AUTHORS

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Thematic 16 : Physiology in cold environments Part II

#46732127
Oral Presentation

Physiological and Performance Consequences of Severe Energy Deficit During Prolonged Cold-Weather Military Ski Patrolling

BACKGROUND
Prolonged military ski patrolling is an operationally relevant task with a high total daily energy expenditure (TDEE). Due to sustained workload, environmental stress and logistical constraints on energy intake (EI), substantial energy deficit is common. This is associated with performance decrements, increased injury and illness risk, and impaired operational effectiveness. Accurate quantification of energy balance (EB) is therefore important to inform nutritional and operational counter-measures to minimise sustained energy deficit.

METHODS
Nine male Commando-trained personnel enrolled on the Royal Marines Mountain Leader course and habituated to arduous physical activity participated in a 5-day cold-weather ski-patrolling exercise in northern Norway (February 2025). TDEE was measured using doubly labelled water (DLW). EI was determined from issued military rations accounting for individual discards. Physical activity was characterised using wrist-worn accelerometery to determine time spent across intensity domains and derive mean metabolic equivalents (METs). Body composition was assessed pre- and post-exercise using stable isotope dilution. EB was calculated as EI − TDEE. Physical performance was assessed pre- and post-exercise. This study was approved by MODREC (2337/MODREC/24). Data are mean ± SD.

RESULTS
Estimated EB was −4064 ± 1056 kcal·d^{-1} (−55 ± 11% of TDEE) based on EI of 2996 ± 586 kcal·d^{-1} and DLW-derived TDEE of 7060 ± 861 kcal·d-1. Across the 5-day duration, 59% of total time was moderate-to-vigorous physical activity (MVPA; 54% moderate; 5% vigorous), corresponding to ~450 kcal·h^{-1} during MVPA (5.2 ± 0.7 METs). Body mass decreased by 3.0 ± 0.9 kg ($p < 0.001$), comprising reductions in fat mass (−2.5 ± 1.6 kg; $p = 0.003$) and fat-free mass (−0.4 ± 1.7 kg; NS). Total body water (TBW), expressed relative to body mass, increased by 2.9 ± 2.3 % ($p = 0.01$). Countermovement jump and isometric mid-thigh pull performance decreased (−12.1 ± 9.3 % and −7.5 ± 6.9 %, respectively; $p <0.05$).

CONCLUSION
Prolonged military ski patrolling produces extreme TDEE accompanied by measurable reductions in physical performance. In this context, where energy intake did not match expenditure, substantial energy deficit occurred. Increases in relative TBW indicate physiological stress-related fluid retention, which may obscure true FFM loss and distort interpretation of body composition change. Fluid-balance dynamics therefore represent an important physiological consideration when interpreting body composition and EB during extreme prolonged physical activity.

MILITARY IMPACT
Arduous multi-day cold-weather ski patrolling imposes substantial metabolic strain. Accurate assessment of TDEE and EB is essential to inform nutritional and operational counter-measures aimed at minimising energy deficit, maintaining operational capability, and mitigating individual and organisational risk during prolonged cold-weather operations.

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Thematic 16 : Physiology in cold environments Part II

#46779342
Oral Presentation

A novel simulation and analysis technology for the study of local responses to cold. A case control study.

BACKGROUND
Cold exposure of the extremities is an environmental stressor with detrimental effects on manual dexterity. In-lab analysis of cold responses in literature is done through a water immersion simulation monitored by thermocouples located on the fingertips, leading to a partial assessment of the hand's heat distribution. Additionally, the water immersion methodology leads to a stronger cooling rate than what would be encountered in environmental scenario. Our objective is therefore to design a cold air exposure test, which would allow for more adequate exposure conditions, for the study of the hand's temperature via infrared thermography, and the assessment of local response patterns of the hand.

METHODS
A climate-controlled exposure was designed, This enclosure was equipped with an observation window for real-time thermographic imaging. Processing of these thermographic images was done via an automatic computer-assisted program for the segmentation and extraction of regions of interest (IRIS-Cam). Additionally, assessment of pain and perceived temperature was done via a dedicated program (TouchSense). Finally, these tools were used during a experimental session (RECOPS, IDRCB : 2023-A01221-44). Twenty-four subjects had their hand exposed to a climate-controlled -5°C air up to the styloid process for a duration of 20 minutes.Results : The enclosure was capable of maintaining an internal air temperature of 5°C to -20°C with a heterogeneity of 1°C between its regulation peaks and within. The IRIS-Cam real-time analysis software is capable of segmenting the digits and phalanges within each thermal image, as well as providing a gradient profile highlighting spatial heterogeneities within these regions.

Results from the RECOPS study showed that the methodology was capable of eliciting local cold responses. The real-time segmentation program allowed for the study of cold-induced vasodilation responses, validating the relevancy of infrared thermography.

Thermal imaging highlighted marked vasoconstrictive patterns, more pronounced between the median and distal phalanges. Cold-Induced Vasodilation happened later on average than with water immersion, and had a marked spatial heterogeneity among the fingers. Sensorial assessment acquired via TouchSense further confirmed this spatial heterogeneity between phalanges, which correlated with the thermographic data.

CONCLUSION
This work proposes a new local cold exposure methodology capable of adequately replicating environmental conditions. The use of thermographic imaging yields a more modular approach to the study of these responses, challenging the reported homogeneity of the fingers in thermal modelling of the hand especially in the context of cold-induced vasodilation.

MILITARY IMPACT
Adequate modelling of cold responses is necessary to detect which response patterns are capable of maintaining finger temperatures above the threshold where dexterity is impaired. These responses, and fine assessment of the cooldown kinetics of the fingers, allow for the development of adaptive cold-exposure countermeasures

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Thematic 16 : Physiology in cold environments Part II

#46802855
Oral Presentation

Attention Control Changes During a Long Range Patrol Operation on Land-Over-Snow-Vehicles in Canadian High Arctic: A Preliminary Study

BACKGROUND

Attention control is important for military task performance (e.g., those that include decision-making, planning and execution of duties) and there are concerns how cognitive function changes across repeated extreme cold exposure. In February to March 2025, the International Cooperative Engagement Program for Polar Research (ICE-PPR) held a scientific Operation as part of Operation NANOOK-NUNALIVUT 2025 with the Canadian Armed Forces in the Canadian Arctic (Northwest Territories). This Operation primarily consisted of long-range patrols on Land-Over-Snow-Vehicles/snowmobiles and sleeping outdoors in heated tents. The purpose of this study was to determine the changes in attention control before (PRE) starting the Operation, at the midpoint (MID, 6 days into Operation), and at the end (POST, 14 days into Operation).

METHODS

11 military personnel (9 Canadian, 1 Finnish, 1 Swedish) completed this study where following familiarization of cognitive test battery (3-5 attempts), participants completed the PRE, MID, and POST testing indoors across the Operation. Attentional control was tested using the Squared Attention Task battery, which consists of a Stroop, Flanker, and Simon Squared task. In each task, participants perform a 30s practice, followed by a 90s test period where the goal is to accumulate as much points as possible (1 correct answer = 1 point, 1 incorrect answer = -1 point). A 1 X 3 (PRE, MID, POST) linear mixed model was used to compare main effects with $p < 0.05$ as significant. If significant, a Bonforroni post-hoc test was used for pairwise comparisons. This study was approved by our institutional human research ethics board (HREC2025-004).

RESULTS

There was no effect ($p = 0.111$) across the Operation for Simon Squared performance. There was a significant effect for Stroop Squared performance ($p=0.016$) where performance was improved at MID (47.0±7.0 points) compared to PRE (43.0±8.0 points, $p=0.038$), and Flanker Squared performance ($p=0.007$), where performance was better at POST (49.0±5.0 points) compared to PRE (43.0±10.0 points, $p=0.029$)

CONCLUSION

Attention control was maintained or improved across the Operation. In this presentation we will discuss how results may be related to learning effect and favourable components of the Operation (such as rest availability).

AUTHORS

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Thematic 16 : Physiology in cold environments Part II

#46393622
Poster Presentation

Exosomes Derived from Human Stem Cells Acts as Early Stabilizer to Ameliorate Symptoms of Cold Stress in Mouse Model

BACKGROUND
Military training and operations in freezing cold conditions adversely impact health and overall performance. Evidence linked the loss of body temperature to the depletion of bioenergy, which could be enhanced by mesenchymal stem cells (MSC) as suggested by independent studies. However, the largely inconsistent protocol to generate MSCs and its complex archiving protocol diminish its therapeutic values. Hence, we investigated an alternative, namely the exosomes derived from human mesenchymal stem cells (ex-hMSC-ex), which could be synthesized with higher consistency and possesses longer shelf-life.

METHODS
Adult female and male C57BL6J mice were exposed to 10min cold stress for 10 consecutive days and humanely euthanized under anaesthesia after the withdrawal of stress. Core body temperature and blood pressure were monitored during the stress. Y-maze study measured the behaviour attributes after the cold stress, and post-mortem heart histopathology study was conducted.

RESULTS
Dose determination study identified that the administration of 1ug or 1.7×108 of extracellular vesicles (EVs) can cross the blood brain barrier and trigger minimum inflammation; hence the administration of 1ug of hMSC-ex in a 5d interval was determined as the optimal protocol. A significant decrease in core body temperature was observed in the cold stressed mice, although the body temperature in female mice remained low for much longer time than the male. hMSC-ex immediately brought thermoneutrality. Cold stress shifted the blood pressure (BP) from baseline with a gender-biased trend; BP was elevated in male mice but diminished in female mice. hMSC-ex shifted the BP towards baseline, but it was not fully normalized within the stipulated episode of the current assay. Histopathology data reported mild cardiomyocyte degeneration in both genders and hMSC-ex significantly reduced the adverse impact. Y-maze study found higher latency to act in a novel situation and reduced working memory in the cold stressed mice. Indeed, hMSC-ex administration improved these behavioural deficiencies. Whole genome transcriptomics analysis of hemibrain and lungs showed a tissue-independent distinct change in the molecular profile by the prophylactic administration of hMSC-ex. Functional analysis found that cold stress activated oxidative stress- and inflammation-related networks and hMSC-ex was able to ameliorate these effects.

CONCLUSION
Prophylactic administration of hMSC-ex minimized the adverse effects of cold stress and showed some indications in using hMSC-ex as a potential early stabilizer.

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Thematic 16 : Physiology in cold environments Part II

#46574503
Poster Presentation

Influence of Tyrosine Supplementation on Cognition and Physiology during Outdoor Cold Stress

BACKGROUND
Cognitive impairment from cold stress is a significant threat in military and occupational settings. While supplementation with tyrosine has been shown to attenuate cognitive decrements during mild, laboratory-based cold stress, its efficacy under more severe, operationally relevant conditions remains unknown. This study examined the efficacy of tyrosine supplementation in ameliorating deficits in cognitive performance during cold-water immersion (CWI) induced severe cold stress conducted during an outdoor military training event. μ

METHODS
In a double-blind, placebo-controlled study, 34 military personnel (mean ± SD age: 27 ± 6 years, height: 176 ± 8 cm, weight: 82.2 ± 12.0 kg) received tyrosine (TYR; 150 mg•kg-1; n = 17) or placebo (PBO; n = 17) before an outdoor 10-min whole-body CWI (air temperature: -2.1°C; water temperature: 0.4°C). Cognitive performance (match-to-sample [MTS]) and physiological measures (core/skin temperature) were assessed prior to, during, and after CWI. Generalized linear mixed models were used to analyze cognitive data for effects of tyrosine supplementation. Physiological data were analyzed using mixed-design analyses of variance. Statistical significance was set at $p < .05$. W

RESULTS
CWI induced significant physiological stress in both groups, with no group differences in core or skin temperature (p's > .05). Temperatures were significantly lower during and after immersion relative to baseline levels (p's < .01). Analysis of MTS reaction time revealed a significant Group x Time interaction ($p < .001$). Within-group comparisons showed that the TYR group exhibited significantly faster reaction times during the pre-immersion and immersion phases compared with their own baseline ($p < .001$), a change not seen in the PBO group. The TYR group also made fewer correct responses on the MTS compared with the PBO group ($p = .04$), while simultaneously producing more omission errors ($p < .01$).

CONCLUSION
Findings indicate that tyrosine supplementation does not prevent overall cognitive impairment during severe cold stress but may instead alter performance strategy. Specifically, tyrosine supplementation elicited faster reaction times on a complex cognitive task; however, this speed was achieved at the cost of reduced accuracy and more errors of omission. This induced speed-accuracy trade-off is a critical consideration when evaluating the viability of tyrosine as a cognitive countermeasure in extreme environments.

AUTHORS

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Thematic 16 : Physiology in cold environments Part II

#46636845
Poster Presentation

Metabolic and Stress-Related Hormone Changes Between Seasons During Cold Weather Military Training

BACKGROUND
Military personnel train and operate in varying environmental conditions. Investigating whether hormonal changes following intense physical training vary by season can support optimal training program development and maintenance of operational readiness.

METHODS
The Mountain Leader Course (MLC) is a 7-week training program held at the US Mountain Warfare Training Center in Bridgeport, CA to train service members in mountain and cold-weather operations. This investigation compared changes in circulating metabolic and stress-related hormones (Total Triiodothyronine (TT3), Free Thyroxine (FT4), Free Triiodothyronine (FT3), Sex Hormone Binding Globulin (SHBG), Dehydroepiandrosterone (DHEA), Insulin-Like Growth Factor 1 (IGF-1)) over time (Pre, Mid, Post) and between seasons (Winter, Summer) via generalized linear modeling (time, season, time*season). Data was collected during two winter (n=29 (2 female); 26±3yrs, 177.0±8.0cm, 87.4±23.6kg) and one summer (n=18, 28±6yrs, 176.2±10.7cm, 82.6±.6kg) MLC. Ethics approval was acquired for all data collection (STUDY22020119).

RESULTS
Significant interaction effects were observed for DHEA ($p<0.001$), such that concentrations were greater at Pre in winter than summer (Δ+4.8±1.4 ng/mL; 95% CI for contrast: 2.0, 7.5; $p=0.001$) and decreased from Pre to Mid (Δ-6.0±1.0ng/mL; -8.4, -3.5; $p<0.001$) and Post (Δ-4.5±0.9ng/mL; -6.5, -2.4; $p<0.001$) in winter compared to an increase from Pre to Mid (Δ4.9±1.4ng/mL; 1.5, 8.3; $p=0.003$), but not Post (Δ0.5±1.2ng/mL; -1.9, 2.9; $p=0.698$), in summer. Significant main effects of time indicate that FT3 decreased ($p=0.016$), such that concentrations were lower at Post (4.6±0.3pg/mL) compared to Pre (5.2±0.2 pg/mL; -1.2, -0.1; $p=0.015$) and Mid (5.1±0.2 pg/mL; -0.5, 0.3; $p=0.049$). SHBG significantly increased ($p<0.001$) from Pre (29.8±2.3 nmol/L), to Mid (36.6±2.5 nmol/L; 1.4, 12.2; $p=0.011$) and Post (43.9±2.7 nmol/L; 7.6, 20.7; $p<0.001$) and IGF-1 decreased ($p<0.001$) from Pre (296.9±14.9 ng/mL) to Mid (262.9±15.9 ng/mL; -64.3, -3.7; $p=0.028$) and Post (216.7±17.7 ng/mL; -122.1, -38.4; $p<0.001$).

A significant main effect of season ($p=0.013$) was observed for FT4, such that concentrations were greater during winter (13.4±0.7 pg/mL) than summer (10.3±1.0 pg/mL). No significant interaction or main effects were observed for TT3 ($p\geq0.774$).

CONCLUSION
Across a 7-week training course, endocrine changes reflect metabolic and stress adaptations to sustained physical and environmental load. Upregulation of FT4 during winter may suggest greater thermoregulatory demand. DHEA demonstrates seasonality, peaking in winter, suggesting either baseline dependent changes or a seasonal-specific adrenal response to prolonged stress. During all seasons, declining FT3 may indicate energy-conserving adaptation despite stable TT3, and changes in IGF-1 and SHBG may reflect suppressed anabolic signaling.

MILITARY IMPACT
While these responses likely support short-term survival and energy conservation during prolonged training, they may also signal increasing physiological strain and reduced recovery capacity over time, with potential implications for performance sustainability and readiness if training duration or load were extended.

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Thematic 16 : Physiology in cold environments Part II

#46707721
Poster Presentation

Chronic Polyphenol Supplementation Effects on Physiological and Cognitive Responses to Cold Water Immersion

BACKGROUND
Polyphenols may mitigate military-relevant cold stress by improving blood flow and priming protective molecular pathways. We aimed to determine if chronic polyphenol supplementation could attenuate cold water immersion (CWI) stress.

METHODS
In a crossover, double-blind, placebo-controlled study, participants (n=14 [7 male, 7 female], age=26±2y) were randomly assigned to consume a polyphenol-rich (500mg flavonoids+700mg anthocyanins) or matched placebo supplement bar for 14 days prior to an in-laboratory 25min CWI (~10°C) test. The CWI test had five stages (baseline, pre-CWI, CWI, post-CWI, recovery) with pre-CWI, CWI, and post-CWI occurring in a cold environmental chamber (~1°C). Each stage (except CWI) was ~10min, and trials were separated by a 1-week washout. Assessments included attention control tasks (psychomotor vigilance task [PVT], antisaccade task; at baseline, pre-/post-CWI, three times during CWI, recovery), salivary stress biomarkers (cortisol, salivary alpha amylase [sAA]; at baseline, CWI [at ~10 and 20min], post-CWI, recovery), and thermal response (core and skin temperature). Dried blood spots were also collected pre/post CWI test for blood metabolome and proteome responses. Repeated measures ANOVAs were used to assess intervention x stage main effects or interactions. Data are presented as means ± SE, and significance was set at $p<.05$.

RESULTS
Overall, mean skin temperature for CWI (24.3±0.7°C), post-CWI (22.5±0.7°C), and recovery (25.2±1.0°C) were lower than baseline (31.3±1.4°C; $p<.001$); however, core temperature response was similar at all stages (~37°C). The sAA levels increased during CWI (550.6±119.6 and 407.2±94.8 U/ml at 10 and 20min CWI, respectively), and post-CWI (466.1±100.0 U/ml) compared to baseline (190±50 U/ml; $p<.001$), but cortisol levels remained stable ($p>.05$). PVT response time was slower during CWI (334, 334, 346ms), post-CWI (355ms), and recovery (335ms) compared to baseline (315ms; $p<.03$). The number of correct responses during the antisaccade task did not differ among stages ($p>.05$). Between groups, no differences were found for the thermal, cognitive, or stress responses ($p>.05$). Proteomics and metabolomics findings will be available in the spring.

CONCLUSION AND MILITARY IMPACT
Chronic polyphenol supplementation did not affect thermal, cognitive, and stress response to CWI. Findings from proteomics and metabolomics may identify important underlying molecular shifts not captured by these measures.

AUTHORS

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Thematic 16 : Physiology in cold environments Part II

#46726061
Poster Presentation

Salivary DNA Methylation Biomarkers for Predicting Frostbite Susceptibility Prior to Arctic Deployment

BACKGROUND
Freezing cold injuries (FCI), such as frostbite, represent a critical threat to Warfighter health and operational readiness in Arctic environments. While demographic factors impact risk, they do not fully account for individual variance in susceptibility under similar environmental conditions. This study aimed to identify salivary DNA methylation (DNAm) signatures prior to cold exposure that differentiate individuals susceptible (CWI+) versus resistant (CWI−) to frostbite.

METHODS
Saliva samples were collected prior to cold exposure from 206 Canadian Armed Forces members (n=103 CWI+; n=103 age-, sex-, and BMI-matched CWI− controls) participating in high-intensity training exercises in the Arctic across two winter cohorts (2023, 2024). Genome-wide DNAm profiling was performed using the Illumina Infinium Human MethylationEPIC v2 BeadChip (>935,000 CpG sites). Differentially methylated genes (DMG) were defined by strict reproducibility across cohorts (meta-analysis $p < 0.05$ and consistent log Fold Change direction) A two-stage hybrid machine learning framework (Lasso feature selection followed by Sequential forward Feature selection by Support Vector Machine (SVM)) was used to develop a prediction algorithm.

RESULTS
Top DMG candidates associated with frostbite susceptibility included FMN2, NUPR1, and PHLDB1, with CWI+ individuals exhibiting significant baseline suppression of neuro-immune and metabolic signaling pathways ($p < 0.005$). Integration with miRNA data revealed that this response is organized around endothelial/hemostatic activation and vascular-tissue interface remodeling. A refined 10-gene DNAm signature was identified that successfully converged on core physiological machinery of cold stress. In cross-validation, the 10-gene model predicted frostbite occurrence prior to exposure with 87.3% Area Under the Curve (AUC), demonstrating high predictive performance (88.1% sensitivity, 80.2% specificity).

CONCLUSION
This is the first study to demonstrate that epigenetic "priming" in saliva can accurately predict frostbite susceptibility prior to occurrence. The stability of the 10-gene DNAm signature across independent cohorts validates the feasibility of using non-invasive baseline screening to identify high-risk individuals.

MILITARY IMPACT
Identifying high-risk Soldiers prior to deployment to extreme environments enables leadership to implement targeted countermeasures, such as optimized clothing distribution, limited exposure durations or work/warm up schedules, and more frequent cold injury monitoring. Rapid point-of-care screening for these molecular markers can reduce frostbite incidence, preserving combat power and mission effectiveness during high-intensity Arctic operations.

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Thematic 16 : Physiology in cold environments Part II

#46728464
Poster Presentation

Study of sleep in cold environments during a 3-week military winter raid in autonomy

BACKGROUND
In high-intensity operational contexts, optimizing sleep is essential to maintain operational capabilities. Sleep can be disturbed by factors like noise, brightness, activity, or temperature, particularly in military environments. Impacts of cold environments on sleep patterns are not well documented. Objective: To qualitatively and quantitatively characterize sleep patterns in soldiers during a Greenland winter raid.

METHODS
Twelve healthy men with no history of colds or sleep disorders participated in a 20-day Greenland expedition in March 2024. They slept in unheated tents with a standard sleeping kit. Daily, they engaged in intense ski and pulka activity. Temperatures were recorded using I-button® sensors in each layer of the sleeping kit, and sleep comfort was assessed with questionnaires. Sleep quality and quantity were evaluated with actigraphy and questionnaires. For the statistical analysis, the raid was divided into three periods (P1, P2, and P3), and each night was split into two equal parts (S1 and S2). Statistical analyses included ANOVA followed by linear regression.

RESULTS
The average outdoor temperature during the nocturnal raid was -21.0°C, while the inside of the tent averaged -16.0°C. Inside the sleeping bag, the temperature reached +33.0°C at the chest and +31.0°C at the feet. The thermal sensation inside the sleeping bag was felt as neither hot nor cold throughout the raid. Sleep data showed increased total sleep time, decreased sleep efficiency, and increased fragmentation during the raid (P1 versus P2 and P3) and compared to a night control in France (France versus Greenland raid). We observed more awakenings during the raid (P1 versus P2, P3) and compared to a night control in France. The second half of the night showed a significant rise in awakenings (S1: 26,9 ± 11,0 vs S2: 32,9 ± 12,5, $p<0.001$) and a decrease in total sleep duration (S1: 4h17 ± 42minvs S2: 4h4 ± 38min, $p<0.001$). The correlation analysis highlights the relationship between foot-level sleeping temperature and actimetry parameters, especially during the second half of the night.

CONCLUSION
For the first time, we describe the sleep patterns of a group of subjects autonomously adapting to a cold C2 environment (NATO classification). Our study highlights an increase in total sleep time, along with greater sleep fragmentation during the raid. Our findings show that the second part of the night primarily drives changes in sleep quality. Additionally, there is a perception bias between perceived sleep quality and objective sleep measurements. These results emphasize the importance of microclimate temperature within the sleeping environment, especially at foot level.

MILITARY IMPACT
Enhanced thermal protection around the feet is essential, especially during the second half of the night, to maintain high-quality sleep and optimize soldiers' performance.

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Thematic 16 : Physiology in cold environments Part II

#46760398
Poster Presentation

Caffeine Supplementaiton to Reduce Physical and Cognitive Fatigue in Soliders Operating in Hypoxic and Cold Environements : a Pilot Field Study

BACKGROUND
Research on the effects of caffeine supplementation in soldiers operating in cold and hypoxic environments is sparse. This pilot field study aimed to investigate the effects of such strategy on the physical and cognitive fatigue of soldiers during a 2-day military exercise on the Mont Blanc (3375m) in December 2025.

METHODS
Twenty alpine soldiers were randomly assigned in a triple-blinded manner to either a caffeine or a placebo group with a 1:1 allocation ratio. Each day, to assess fatigue, participants were tested before and after a military exercise consisting of 4-hour technical navigation on the Gigante glacier. The pre-test included the Groningen Sleep Quality Scale (GSQS), the Italian Mood Scale (ITAMS), a 5-min psychomotor vigilance task (PVT), and a 5-min step test during which heart rate (HR), blood lactate concentration (bLA) and ratings of perceived exertion (RPE) for legs and breathing were measured. Immediately after the pre-test and 3 hours into the military exercise, participants ingested pills containing 200mg of caffeine or placebo for a total of 400 mg of caffeine. The military exercise workload was quantified with wearables and the NASA-TLX. Apart from the GSQS, the same pre-test measures were repeated after the military exercise (post-test). During nights, soldiers slept in tents and wore actigraphs to record sleep parameters. Data were analysed using mixed models with Gamma distribution; data clustered in subjects and selected as random effects intercept. Time, Drug and Day treated as fixed factors.

RESULTS
Caffeine supplementation significantly reduced the negative effects of fatigue on reaction time (ms) [Group*Time b=-15.96; SE=6.84; CI95%=(-29.36 to -2.55); p=0.020] and number of lapses [Group*Time b=-3.34; SE=0.97; CI95%=(-5.25 to -1.43); p<.001] during the PVT, Vigor (0-16 scale) [Group*Time b=0.81; SE=0.40; CI95%=(0.02 to 1.61); p=0.044], and RPE-Legs (0-10 scale) [Group*Time b=-1.44; SE=0.55; CI95%=(-2.51 to -0.37); p=0.008]. No significant effects of caffeine were found on RPE-Breathing, HR, bLA, other mood dimensions, and sleep. The latter was poor during the nights preceding the military exercise (total sleep time 4:37±1:27; GSQS 8.2±3.9, with scores over 6 indicating poor sleep quality).

CONCLUSION AND MILITARY IMPACT
The results of this pilot field study suggest that supplementation with 400 mg of caffeine is able to reduce the physical and cognitive fatigue experienced by soldiers operating in cold and hypoxic environments without further disrupting their sleep. Pending confirmation in larger trials, these findings extend the use of caffeine supplementation for military purposes in soldiers deployed in these extreme environments.

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Thematic 16 : Physiology in cold environments Part II

#46786814
Poster Presentation

Single Nucleotide Polymorphisms in FADS2, LRP5, and PRKG1 are Associated with Frostbite Susceptibility in Military Personnel Deployed to Arctic Regions

BACKGROUND
Arctic operations can expose Warfighters to extreme cold, increasing the risk of freezing cold injuries (FCI) such as frostbite. Recent evidence suggests that specific genetic variants identified in polar-dwelling populations may influence cold tolerance and vascular resilience, which may affect individual susceptibility to FCIs. This study utilized a targeted candidate-gene and genome-wide association study (GWAS) approach to identify single nucleotide polymorphisms (SNPs) associated with frostbite susceptibility in military personnel deployed to Arctic training exercises.

METHODS
DNA was extracted from baseline saliva samples in 206 Canadian Armed Forces members (n=103 frostbite-injured FCI+; n=103 age-, sex-, and BMI-matched controls FCI−) participating in high-intensity Arctic training exercises. Targeted SNP profiling was performed using the Infinium Global Screening Array BeadChip. Logistic regression models tested associations across 245 targeted variants within loci previously implicated in cold adaptation (FADS2, FADS3, CPT1A, LRP5, PRKG1, TRPM8). Multiple testing was corrected using the Meff method to account for mathematically independent DNA blocks.

RESULTS
Analysis identified significant associations (FDR < 0.05) across three primary regulatory loci. The strongest signal occurred within the FADS2 locus (rs174593), followed by significant clusters in LRP5 (rs660925) and PRKG1 (rs6480375). Specifically, FADS2 variants encode enzymes that convert dietary fatty acids into arachidonic acid which can contribute to an excessive inflammatory response and more violent and destructive reperfusion injury. LRP5 variants are responsible for building and maintaining strong stable blood vessels and given that frostbite is fundamentally a vascular injury due to ice crystals shredding cell linings and causing blood vessels to become leaky and unstable, individuals with a hyperactive LRP5 variant ensure that the blood vessel walls are strong. PRKG1 variants likely compromise the protective "hunting response" (cold-induced vasodilation), thereby increasing individual susceptibility to frostbite. These genetic signatures effectively differentiate susceptible individuals from resistant controls prior to environmental exposure.

CONCLUSION
This study provides robust evidence that specific gene variants in FADS2, LRP5, and PRKG1 are significantly linked to frostbite risk. By utilizing Meff-based FDR correction, we showed that genetic predisposition contributes to cold-injury risk, validating these loci as actionable targets for predictive screening in military populations.

MILITARY IMPACT
Identifying Warfighters carrying high-risk alleles in metabolic and vascular pathways allows leadership to implement proactive targeted countermeasures (e.g., precision clothing distribution, optimized exposure limits) to maintain operational effectiveness and reduce injury risk in the Arctic. Disclaimer: Authors' views not official U.S. Army or DoW policy.

AUTHORS

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Thematic 16 : Physiology in cold environments Part II

#46811737
Poster Presentation

A 24-hour cold exposure simulation in humans: peripheral blood transcriptomics reveal stable gene expression with selective immunometabolic regulation

BACKGROUND

Prolonged cold exposure challenges thermoregulation and operational performance, yet systems-level molecular signatures of sustained cold stress in humans remain poorly defined. We profiled peripheral blood leukocyte gene expression during a 24-hour whole-body cold survival simulation designed to mimic austere Northern climate exposure conditions, with pre- and post-cold exercises.

METHODS

Eight healthy adult males completed standardized treadmill walking (5 km at 50% peak oxygen uptake) immediately before and after a 24-hour exposure to 7.5°C (50% relative humidity; <1 $m \cdot s^{-1}$ air movement) without external heat aids. Blood was collected at baseline (0 h), post–pre-cold exercise (1 h), post-cold (24 h), and post–post-cold exercise (~5 h). Two participants did not complete the full exposure and were excluded from transcriptomic analyses (final n=6). Microarray data were analyzed in R using linear models with false discovery rate (FDR) correction (α=0.05) for differential expression assessment and pathway enrichment analysis. Given the exploratory pilot design (no genes passed FDR), focused differential-expression signals were evaluated at $p<0.001$; KEGG pathway enrichment used FDR-adjusted $p<0.05$.

RESULTS

Global leukocyte transcriptomic profiles remained stable across timepoints, with no clear separation by exposure condition in clustering/ordination analyses. Physiological strain was evident, including a 0.6°C decline in core temperature and an 869 kcal energy deficit across the exposure. Thirteen genes met the pilot differential-expression threshold across comparisons, with transient exercise-linked induction of immediate-early/stress genes (e.g., TAGAP $p=5.02\times10^{-5}$; FOS $p=7.99\times10^{-5}$; TIPARP $p=5.13\times10^{-5}$) that returned toward baseline after cold exposure. Pathway enrichment indicated upregulated immune/stress signaling after pre-cold exercise (B-cell receptor, MAPK, Toll-like receptor pathways; adjusted $p\approx0.046$), while post-cold comparisons showed enrichment of metabolic pathways (e.g., glycolysis/gluconeogenesis and oxidative phosphorylation; adjusted $p\approx0.037$).

CONCLUSION

During 24 hours of continuous mild cold exposure, peripheral blood leukocyte gene expression demonstrated marked homeostasis, with selective, time-locked immunometabolic regulation rather than broad inflammatory activation. Intermittent exercise appeared to be a primary driver of the detectable transcriptional signals.

MILITARY IMPACT

These findings support the feasibility of blood-based transcriptomic surveillance during prolonged cold stress and suggest a resilient, energy-efficient molecular phenotype that may help sustain function in cold-weather operations. This work informs biomarker development, predictive monitoring, and precision countermeasures to prepare and endure high-intensity conflicts in cold and austere environments.

AUTHORS

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Thematic 16 :
Physiology in cold environments Part II

#47183033
Poster Presentation

High Altitude High Open (HAHO) parachuting : case report of a face frostbite

BACKGROUND

HAHO jumps involve physiological risks like hypobaric hypoxia, opening shock, harness syndrome, and thermal risk. We report a winter frostbite incident during an operational jump in France, raising questions about risk assessment, atypical frostbite management, and prevention through parachutist training. History of the accident: Six experienced paratroopers made this jump with equipment including a harness, parachute, flight gear, and oxygen system. Their cold-weather outfit covered shoes, overshoes, heated gloves, a balaclava (commercial and custom), goggles, and a cold-weather suit. Thermal insulation was tested in an IRBA climatic chamber and achieved a measured value of over 3.5 Clo. During the jump, skin temperature was monitored using four thermistor probes (left index finger pulp, left toe pulp, left cheekbone, and left hemithorax). External temperature was measured with an Ibutton® on the jacket. The environmental data from the jump indicate that, at release, the cargo bay temperature recorded by the aircraft was -51 °C, and the ground temperature was +10 °C. The jump duration was 43 minutes. During this jump, the paratroopers experienced temperatures below 0 °C for 25 minutes, below -20 °C for 13 minutes, and below -30 °C for 6 minutes. The estimated relative wind speed was less than 10 m/s (air mass displacement). Upon landing, three parachutists reported facial pain and a strong cold sensation in their hands, along with a loss of manual dexterity. They also experienced a gradual cold feeling in their feet. Medical examination revealed that, among the three paratroopers wearing commercial balaclavas, frostbite was present on the face (bilateral cheekbones), with one parachutist showing a significant inflammatory reaction. Medical care was provided by the jump's doctor. The classification of frostbite severity differed from that of the frostbite on their feet and hands, as classification cannot be performed after active rewarming. Ultimately, two parachutists had stage 1 frostbite, and one had stage 2 frostbite. The estimated operational incapacity was one month.

CONCLUSION

This accident highlights the importance of risk assessment before taking action. A temperature drop to -50°C demands full protection of exposed skin. Frostbite can occur within a minute under these conditions. The wind significantly exacerbates the risk. Face protection should include a balaclava that covers the skin, compatible with oxygen masks, goggles, communication systems, and ballistic helmets. We recommend wearing this balaclava routinely when the temperature falls below -30°C. The medical treatment for frostbite on the face is different from that for frostbite on the feet and hands. Paratroopers need to understand this type of frostbite and how to treat it. This kind of frostbite can result in a longer recovery time and may lead to complications like dysesthesia.Preventing this type of accident involves developing textile solutions such as heated gloves, custom balaclavas, and overshoes, and training skydivers on thermal risks—recognizing signs, anticipating issues, and using validated gear.

MILITARY IMPACT

HAHO-type parachute jumps enable new military capabilities but also pose health risks to paratroopers. To mitigate these risks, developing countermeasures is crucial. These include technological solutions, such as heated gloves, complemented by training for paratroopers and medical personnel.

AUTHORS

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Thematic 17 : Soldiers in extreme environment (diving + confined spaces)

Salle Lucienne et André Blin - Mod: J. Greeves + G. Giersch

ORAL PRESENTATIONS

Muscle activity and kinematics of fin swimming of professional divers

Impact of submarine motion on tactile interaction performance: Implications for naval operability

Increased Thermal Strain in Tracked Vehicle Crew Uniforms under Hot-Humid Conditions

Changes in body composition of Finnish Navy divers during an intensive diving training in cold water

Thematic 17 : Soldiers in extreme environment (diving + confined spaces)

#46246166
Oral Presentation

Muscle activity and kinematics of fin swimming of professional divers

BACKGROUND
Understanding the activation pattern of different muscles relative to the joint angles of the lower body in professional divers is essential for teaching proper technique and providing appropriate training protocols to enhance performance. The purpose of this study is to describe the kinematics and muscle activation of the fin swimming of professional divers.

METHODS
Eight professional divers performed a trial of fin swimming in a counter current pool at 4 min/100m. Muscular activity and lower body kinematics were evaluated during the exercise by 8 surface Electromyograms and 7 Inertial Measurement Units. Mean EMG and maximal activation were measured for Biceps Femoris (BF), Rectus Femoris (RF), Semi Tendinosis (ST), Vastus Lateralis (VL), Soleus (Sol), Gastrocnemius Medialis (GM), Tibialis Anterior (TA), Gluteus maximus (Glut).

RESULTS
The average range of motion of knee, ankle and hip joints were 75°, 64° and 52°, respectively. Mean activation were 9% of maximal voluntary contraction (MVC) for RF, 5%MVC for VL and 5%MVC for TA with maximum activation at 33, 17 and 15 %MVC. Mean activation were of 10%MVC for GM, 11%MVC for Sol, 13%MVC for BF and 7%MVC for ST and 2% for Glut with maximum activation at respectively 4, 29 and 47, 21 and 4%MVC.

CONCLUSION
Most engaged muscles in fin swimming were RF, BF, GM, Sol and ST. These muscles were activated while the knee, ankle, and hip joints moved through ranges of motion of 75°, 64°, and 52°, respectively. This knowledge is essential for teaching proper fin swimming technique and providing appropriate training protocols to enhance the performance of sport, professional, or military divers.

MILITARY IMPACT
From an operational standpoint, this study provides key biomechanical data to optimize fin swimming performance. The identification of primary engaged muscles (BF, ST, GM, RF, Sol) and their specific joint angles offers an objective basis for both technique correction and targeted strength conditioning.

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Thematic 17 : Soldiers in extreme environment (diving + confined spaces)

#46744323
Oral Presentation

Impact of submarine motion on tactile interaction performance: Implications for naval operability

BACKGROUND
In high-intensity maritime conflicts, submarines frequently operate at periscope depth to conduct critical intelligence and tactical tasks before deploying optronic masts. At this specific depth, the submarine is highly susceptible to sea-state-induced platform motions. While modern combat systems increasingly rely on touchscreen interfaces for rapid data processing, the impact of these continuous multi-axis naval ship motions on operator tactile precision remains poorly understood.

METHODS
Twenty-two right-handed students (9 Females; age: 18.9 ± 1.2 years) participated. The experiment was conducted using a motion tripod simulating maritime conditions: Static, Roll (±6°, 10s period), and Pitch (±7°, 3.7s period). Seated participants performed a touch-pointing task under each of these three randomized states. Stimuli were presented on a simulation screen controlled on a laptop and touch interactions were recorded. A total of 72 targets (6 distinct targets, 12 repetitions each) were presented in a randomized sequence, and participants were required to point at each target specifically when it turned red. Each stimulus was synchronized every 10 seconds tracking real-time platform coordinates. A two-way repeated measures ANOVA was conducted to examine the effects of platform motion and target position on interaction success rate, distance and response time.

RESULTS
Statistical analysis showed that while pitch motion significantly degraded global success rates, the impact varied according to target position, revealing specific zones of vulnerability and paradoxical adaptation. Statistical analysis revealed a significant main effect of platform motion on task success ($p = 0.0093$). Pitch was the most disruptive condition with a mean success rate of 74.4%, compared to 78.1% in Roll and 78.8% in Static conditions, which were statistically identical ($p > 0.05$). Target location also showed a critical impact ($p < 0.0001$). Target 3 (bottom left) was identified as the most difficult with a 70.0% success rate, significantly lower than the 78.6% average observed for all other positions ($p < 0.05$).

A significant interaction between motion and position was found for Target 6 (bottom right), which showed high vulnerability to Pitch ($p = 0.0183$), and Target 2 (center left), where participants paradoxically performed better during motion ($p < 0.001$). While motion affected the success rate, it did not significantly increase the spatial distance of misses ($p = 0.2333$). Notably, misses on Target 6 were proximal to the boundaries, whereas Target 4 yielded significantly larger spatial offsets ($p < 0.0001$).

CONCLUSION
This study demonstrates that submarine platform motion at periscope depth specifically degrades tactile precision during pitching moments. The results highlight that error patterns are non-uniform across the interface: bottom-left and top-right zones represent high-risk areas for tactical interaction. The stability of error distances despite motion suggests that operators maintain control but fail at the boundary threshold of standardized target sizes.

MILITARY IMPACT
In high-intensity naval conflicts, where rapid response is vital, these findings recommend a redesign of submarine Human-Machine Interfaces (HMI). Critical tactical triggers should be relocated away from the bottom-left and top-right quadrants to minimize operational errors during periscope-depth maneuvers. Furthermore, the sensitivity of standard-sized targets to pitch motion suggests that adaptive interfaces or "dynamic damping" of touch zones could enhance operator lethality and vessel safety in rough seas.

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Thematic 17 : Soldiers in extreme environment (diving + confined spaces)

#46781355
Oral Presentation

Increased Thermal Strain in Tracked Vehicle Crew Uniforms under Hot-Humid Conditions

BACKGROUND
The tracked vehicle crew uniform in Korea is made of a flame-resistant rayon/aramid blended fabric. However, the high-temperature environment inside the tracked vehicles without air conditioning during summer may exacerbate soldiers' thermal strain. This study aimed to quantify heat strain by comparing the standard combat uniform and the tracked vehicle crew uniform under thermo-neutral and hot-humid environments.

METHODS
Eight males completed two clothing conditions (the standard combat uniform [STANDARD] and the tracked vehicle crew uniform [TRACKED]) in the following two environmental conditions (25°C, 50%RH; 34°C, 60%RH). Each trial lasted 70 min (10-min rest, 30-min load carriage, 20-min arm exercise, and 10-min recovery).

RESULTS
Core temperature was significantly higher in TRACKED than in STANDARD during the arm exercise and recovery under the 34°C condition ($P < 0.05$), whereas no significant difference was observed under the 25°C condition. Mean skin temperature did not differ between clothing conditions; however, it was on average more than 2.5°C higher at 34°C than at 25°C, reaching 36.3–36.4°C under the hot condition ($P < 0.05$). The clothing microclimate humidity at the chest reached 90%RH at 25- min exposure under the 34°C condition and at 50-min under the 25°C condition, with no significant difference between clothing conditions. Heart rate during arm exercise at 34°C was significantly higher in TRACKED compared with STANDARD (132 ± 21 bpm vs. 125 ± 21 bpm). Under the 34°C condition, thermal discomfort was significantly greater in TRACKED than in STANDARD ($P < 0.05$). For perceived wetness, a significant difference between clothing conditions was observed during the rest period ($P < 0.05$).

CONCLUSION
These findings suggest that wearing the tracked vehicle crew uniform may increase thermal strain during summer operations. However, the flame resistance and durability of the uniform material are critical functional properties, making simple replacement impractical. The development of summer-specific crew uniforms and the implementation of active personal cooling garments may help mitigate physiological strain and enhance operational performance.

MILITARY IMPACT
This study highlights the need to balance flame protection with thermal burden in armored vehicle operations. Climate-adaptive uniform systems may enhance mission sustainability and reduce physiological risk in extreme environments.

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Thematic 17 : Soldiers in extreme environment (diving + confined spaces)

#46808388
Oral Presentation

Changes in body composition of Finnish Navy divers during an intensive diving training in cold water

BACKGROUND
Military divers are exposed to various environmental factors that can affect their performance. Measuring body composition can provide information on changes in their ability to fulfill given mission successfully. The most accurate method to estimate body composition imaging technologies such as Dual-energy X-ray Absorptiometry (DXA) or Position Emission Tomography (PET) / Computed tomography (CT) scans. However, the most common and accessible method remain bioimpedance – analysis (BIA), which is easy and fast to use. We compared estimations of body composition of soldiers who attended a navy divers´ course before (PRE) and after (POST) with BIA and PET/CT.

METHODS
A total of 28 voluntary male soldiers took part in the study. Body composition was estimated with a four site multi frequency InBody 770 (BioSpace, Republic of Korea) bioimpedance device and compared to CT - images acquired using a long axial field of view PET / CT - scanner Biograph Vision Quadra (Siemens Healthineers, Germany). Participants were imaged in a supine position with arms placed on the side. Ultra-low-dose (effective dose 0.7 mSv) was used for CT and the images were reconstructed to a 512 × 512 × 380 matrix with a voxel size of 0.977 × 0.977 × 2.80 mm3. Further, the volume and radiodensity (Hounsfield units, HU) of skeletal muscles, subcutaneous adipose tissue and visceral adipose tissue were determined form CT-images. The imaging data was analyzed in two ways: using automatic segmentation by TotalSegmentator (https://github.com/wasserth/TotalSegmentator) to quantify total tissue volumes and by semi-automatic segmentation of the tissue areas at L3 level, which was used to estimate total body tissue volumes. Changes in tissue volumes and radiodensity were analyzed using a paired t-test to evaluate within-subject changes over time. Continuous variables are presented as mean ± standard deviation (SD). The study was given an ethical approval from the Medical Research Ethics Committee of the wellbeing services county of Southwest Finland (VARHA/23046/13.02.02/2023) and also authorization from the Finnish Defence Forces (AU6275 and AU31047). All participants were informed of the experimental design, methods, benefits, and possible risks prior to signing an informed consent document.

RESULTS
No statistically significant differences were observed in CT and BIA scan for muscle, subcutaneous and visceral fat volume. There was statistically significant increase in skeletal muscle HU value PRE 40,71±4,28 vs. POST 42,81±4,62 ($p<0,05$).

CONCLUSION
There were no significant changes found during a Finnish Navy diver course in body composition in either BIA or CT measurements. However, skeletal muscle HU, was increased as an indicator of decreased fat content in the muscle. Higher skeletal muscle HU value has been found to correlate with higher strength and metabolically healthier muscle tissue. This could indicate that although the divers´ course did not change the body composition of the soldiers, it may influence functional muscle tissue remodelling, and consequently physical performance related to diving tasks.

MILITARY IMPACT
All kind of military training exposes soldiers to sustained physical and psychological stressors, which can lead decreases in performance. It is important to follow physical and psychological state of the soldiers during training, but also their body composition to be able to see possible changes in their performance.

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Thematic 18 : Aerospace physiology

Le Grand Salon - A. Pavy-Le Traon + I. Mekjavic

ORAL PRESENTATIONS

Monitoring physiological status of military pilot trainees with the Flight Sense System

Peak Cervical Spine Loading During Fast Jet Operations Exceeds Standard Conditioning Intensity: Preliminary Flight Analysis

Continuous monitoring for stress evaluation in fighter pilots to support fit for duty evaluations – preliminary findings

Operational Cervical Movement and Cumulative Spinal Load in Rotary-Wing Aircrew: Effects of Role and Helmet Configuration

POSTER PRESENTATIONS

MAG STATIC TRAINER: an innovative biofeedback-based simulator for anti-G straining maneuvers training in fighter pilots

In-Flight Exercise Guide for Fighter Pilots: A Feasible Tool to Reduce Musculoskeletal Disorders and Support Operational Performance

Thermal Performance of Graphene-Reinforced PVC for Spacesuit Liquid Cooling Garment Applications

Changes in coordination motor skills between air force cadets and experienced military pilots during survival training

Thematic 18 :
Aerospace physiology

#46748474
Oral Presentation

Monitoring physiological status of military pilot trainees with the Flight Sense System

BACKGROUND
Military aircrews are exposed to high accelerations up to +9Gz during flight, which can cause visual disturbances such as gray-out, blackout or G-induced loss of consciousness (G-LOC). Monitoring the heart rate response of trainees might help to evaluate training and improve performance and flight safety. Therefore, a custom-made Flight Sense System (FSS) was developed for the Dutch Defense organization was tested during Gz-exposure training. The aim of this study is to demonstrate face validity of the FSS for monitoring physiological status during G-training.

METHODS
A total of 13 fighter pilot trainees (24.3 ± 2.7 y, 74.4± 6.2 kg, 1.83 ± 0.06 m) followed a human centrifuge training at the Center for Man and Aviation (CML, Soesterberg, The Netherlands). The centrifuge training consisted of a baseline measurement, a Gradual Onset Run (0.1Gz/s2) , Rapid Onset Run to 4Gz (0.33 Gz/s2) and a Rapid Onset Run (1Gz/s2) to max. 5Gz. The heart rate response was monitored using the Flight Sense System. Open-source software (Neurokit2, Python, v3.10) was used to process the physiological signals and assess signal quality. A Repeated measures ANOVA test with generalized eta squared was used to assess differences in heart rate. A Tukey post hoc test was conducted to assess differences between training phases.

RESULTS
In 38 of the 52 measurements (73%) the Flight Sense System had excellent signal quality. In the other cases quality scored barely acceptable (27%). Furthermore, the results revealed significant differences in heart rate between training phases ($p < 0.001$, $\eta 2 = 0.66$ (0.55 – 1.00). Compared to baseline average (95 ± 15 bpm), maximal heart rate increased (G1: 156 ± 18 bpm, G2: 162 ± 13 bpm, G3: 168 ± 11bpm). The heart rate between resting periods remained similar.

CONCLUSION
The results show good face validity of the Flight Sense System and that it can be practically used during centrifuge training for performance optimization. Future studies should further evaluate the system's validity during increased Gz exposure and compare outcomes with golden standard equipment and other commercial devices.

MILITARY IMPACT
Monitoring the physiological status of military aircrew with wearable technologies, such as the Flight Sense System, helps to better understand the physical demands of high Gz-exposure. This information can subsequently be used for training and performance optimization purposes in order to prepare military aircrew for important operations

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Thematic 18 : Aerospace physiology

#46789085
Oral Presentation

Peak Cervical Spine Loading During Fast Jet Operations Exceeds Standard Conditioning Intensity: Preliminary Flight Analysis

BACKGROUND

Fast jet aircrew are exposed to high acceleration forces that impose substantial cervical loading during sustained positive Gz manoeuvres. Under +Gz, head-supported mass increases proportionally to acceleration, amplifying inertial demand at the cervical spine. When the head is positioned in extension, acceleration vectors generate large flexion moments, requiring substantial activation of the cervical flexor musculature to maintain visual tracking and mission performance. Repeated exposure to high-G manoeuvres has been associated with neck complaints and reduced performance. Conditioning programs for injury prevention typically prescribe resistance exercises targeting 40–60% of maximal voluntary contraction (MVC). Whether these prescriptions reproduce operational torque magnitudes and cumulative loading remains unclear.

METHODS

Cervical motion was measured during an operational Hawk training sortie (43 minutes) using inertial sensors. Data were processed through a validated OpenSim inverse-dynamics modelling pipeline to calculate resultant joint moments at C7. Head-supported mass was modelled as 8% of body mass (75 kg) plus helmet mass (JHMCS 1.95 kg). Outcomes included mean and peak C7 torque (Nm), cumulative load (kgf·min), head acceleration (G), and event frequency. Cervical MVC values were obtained from seated fast jet aircrew dynamometry (flexion ~42 Nm; extension ~56 Nm; lateral flexion ~28 Nm; rotation ~26 Nm). Conditioning loads were derived from manufacturer-reported single elastic tubing resistance at 100% elongation using a 0.20 m lever arm.

RESULTS

Maximum resultant head acceleration reached 5.7 G. Mean C7 torque during flight was 18.2 Nm. This corresponded to approximately 32% of extension MVC and 43% of flexion MVC, but 65–70% when compared with lateral flexion and rotation MVC values. Peak torque at C7 reached 33.2 Nm. Relative to single-plane MVC values, this represented 59% of extension MVC, 79% of flexion MVC, and exceeded lateral flexion and rotation MVC magnitudes when compared individually.

High torque events occurred predominantly in extended head positions under positive Gz, indicating substantial flexor loading during manoeuvre. Cumulative exposure during the sortie was 67.8 kgf·min across 63 high-load episodes. Single-tube resistance band generated 6–10 Nm of external moment (approximately 10–35% MVC depending on plane). Mean in-flight torque was therefore approximately 1.8–3.0 times greater than prescribed tubing intensity, and peak torque was 3.3–5.5 times greater.

CONCLUSION

In this preliminary fast jet sortie analysis, operational cervical loading frequently approached or exceeded commonly prescribed conditioning intensity targets. Peak flexor demand during extended head positions under positive Gz substantially exceeded the external moment delivered by standard single-tube resistance prescriptions.

MILITARY IMPACT

Conditioning protocols that do not replicate operational torque magnitudes, acceleration-amplified head mass effects, and head-position–specific loading patterns may inadequately prepare aircrew for sustained acceleration environments. Objective, torque-calibrated training prescriptions aligned with measured in-flight intensity profiles may improve fatigue resistance, reduce neck injury risk, and enhance operational resilience.

AUTHORS

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Thematic 18 : Aerospace physiology

#46725748
Oral Presentation

Continuous monitoring for stress evaluation in fighter pilots to support fit for duty evaluations – preliminary findings

BACKGROUND

Fighter pilots operate under extreme conditions, requiring sustained high performance and vigilance. To assess concentration fatigue and stress exposure, recent research has increasingly shifted towards vital sign monitor-ing. Incorporating non-invasive sensors increases the level of continuous insight and avoids disrupting training environments and simulations, as traditional assessments like cognition tasks such as the NASA questionnaires are prone to. Because pilots already wear extensive equipment, work in noisy settings, and experience rapid physiological changes, monitoring can be challenging and demands innovative, real time measurement ap-proaches. This preliminary study examined stress responses during Swiss Air Force pilot training, focusing on G-Force and hypoxia exposures measured with textile-based wearable systems.

METHODS

Wearable monitoring vests eqO2+ LifeMonitor (Equivital) and custom-developed monitoring belts from Empa were used to acquire electrocardiography (ECG) and respiratory signals in pilot aspirants during a G-force qualification protocol (15 s exposures to 4.5g, 6g, and 7.5g; n = 15) and during hypobaric-hypoxia training at simulated altitudes of 7500 m and 9000 m. In addition, experienced pilots (n=5) were monitored during G-force exposure (4.5-9g) in preparation for new aircraft capabilities. The stress responses were derived from changes in ECG-derived heart activity and breathing rate relative to baseline measures, including the analysis of variance (ANOVA). ECG signal quality was quantified using previously established and newly developed al-gorithms.

RESULTS

ECG signal quality analysis showed a decrease in quality during high G-loads, depending on the selected measurement system. While remaining sufficient for general analysis, it highlights the need for high-quality measures in continuous monitoring systems in extreme conditions. Overall, heart rate increased by 90–120% during G-exposures, without a clear G-level-dependent pattern across pilots. Overall, an interpersonal increase in heart rate post-G-load exposure was found, as well as differences between novice and experienced pilots to the same G-load. The detected breathing rate rose by 14–16% at 6g and 7.5g but remained unchanged at 4.5g. Hypoxia provoked a stronger respiratory response, with breathing rate increasing by 53–62%, while heart rate increased by 6–8%.

CONCLUSION AND MILITARY IMPACT

These findings show that textile-based monitoring systems enable unobtrusive, reliable physiological meas-urements across diverse and demanding training conditions encountered by fighter pilots. While intra- and inter-individual variability in physiological responses was captured, the results demonstrate the potential for detecting acute stress response in extreme environments, highlight the value of individualized insights, and emphasize the importance of selecting appropriate monitoring solutions. These findings under-score the need for further research into cumulative-strain assessment solutions for fitness-for-duty evaluations, ultimately enhancing pilot safety and operational decision-making.

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Thematic 18 : Aerospace physiology

#46788780
Oral Presentation

Operational Cervical Movement and Cumulative Spinal Load in Rotary-Wing Aircrew: Effects of Role and Helmet Configuration

BACKGROUND
Cervical spine pain is highly prevalent in rotary-wing aircrew and is associated with cumulative occupational loading, sustained postures, and helmet-mounted equipment. Despite recognised risk, objective in-flight quantification of cervical movement frequency and cumulative spinal load across operational configurations remains limited. This study quantified cervical motion events and cumulative spinal loading during operational missions and examined the influence of aircrew role and helmet configuration.

METHODS
Aircrew operating the MH-60R platform wore inertial measurement sensors integrated into approved flight garments during routine sorties. Sensors quantified cervical motion events, and cumulative spinal load at C7 (kgf·min) was calculated via validated Opensim processing, normalised per flight hour. Cumulative load was converted to a desk-work equivalent metric to contextualise operational exposure relative to sedentary occupational loading. Linear mixed-effects modelling estimated the independent effects of helmet configuration (standard vs NVG), aircrew role, flight duration, and head-movement frequency. NVG exposure was modelled rather than directly observed across separate missions, with repeated-measures clustering by aircrew member.

RESULTS
Eight operational flights from eight aircrew were analysed. Cumulative spinal load was significantly higher under NVG configuration, with model estimates indicating a 19.3 kgf·min increase compared with the standard helmet ($F_{1,11}$=185.05, p<.001). Each hour of rotary-wing flight generated cervical loading equivalent to approximately 1.5 hours of desk-based occupational exposure under the standard helmet, increasing to 1.7 desk-work hours per flight hour when NVGs were worn. Accordingly, a typical 2-hour sortie produced loading comparable to approximately 3 hours of sustained desk-based exposure, rising to more than 3.5 hours under NVG configuration.

Aircrew role independently influenced cumulative load ($F_{1,11}$=11.62, p=.006), with aircrewmen demonstrating 21.6 kgf·min greater exposure than pilots. Head-movement frequency was not independently associated with cumulative load (p=.876).

CONCLUSION
Operational cervical loading in rotary-wing aviation is substantially amplified by helmet configuration and mission duration, with additional exposure differences across aircrew roles. Cumulative load appears to be driven predominantly by sustained loading and equipment mass rather than movement frequency alone.

MILITARY IMPACT
Configuration-specific quantification of cervical loading demonstrates that routine rotary-wing missions generate occupational exposure exceeding flight duration. These findings provide objective evidence to inform equipment selection, mission planning, and musculoskeletal risk mitigation strategies in military aviation.

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Thematic 18 :
Aerospace physiology

#47130532
Poster Presentation

MAG STATIC TRAINER: an innovative biofeedback-based simulator for anti-G straining maneuvers training in fighter pilots

BACKGROUND

Fighter aircraft expose pilots to high-sustained G-forces, which sometimes exceed physiological tolerance limits and cause visual impairments or even almost loss of consciousness (A-LOC) or G-induced loss of consciousness (G-LOC). These in-flight impairments may lead to fatal accidents. Preventing them is a challenge for aviation safety. Anti-G straining maneuvers (AGSM) are the most effective active countermeasure for increasing physiological tolerance to acceleration, but they require psychomotor training. To improve AGSM, we developed an innovative training simulator (MAG TRAINER) integrating biofeedback and automated performance analysis, and we assessed user satisfaction among pilots and instructors.

METHODS

French aeromedical training consists of 3 phases: a theoretical briefing, a static phase on the ground with training in AGSM on the MAG TRAINER, and a dynamic phase with 4 centrifuge launches. AGSM are composed of synchronized muscle contractions and breath-holding. They must meet criteria such as anticipation, duration of breath holding and contractions, synchronization, modulation and prolongation. The MAG TRAINER displays real-time and delayed performance curves and automatically analyses execution criteria through a scoring system during 4 exercise scenarios combined with cognitive tasks. The system includes a gamer seat with a computer, a large screen and rudder pedals fitted with pressure sensors. The learner is equipped with optional electromyographic electrodes on the quadriceps and hamstring muscles and a headset microphone that records respiratory pattern. User satisfaction was assessed using a simple questionnaire.

RESULTS

The MAG TRAINER was evaluated in 497 fighter and student pilots and navigators. User satisfaction reached 96% among learners and 100% among instructors. The learning session lasted approximately 15 minutes and enabled rapid acquisition and objective evaluation of AGSM performance. The MAG TRAINER is sufficiently easy to use that pilots can train independently or instruct a colleague after their own training.

CONCLUSION

To our knowledge, MAG TRAINER is the first simple and user-friendly educational tool for learning AGSM with automatic analysis of the criteria for successful completion. The simulator allows objective assessment of AGSM execution and facilitates rapid acquisition of correct performance criteria. It provides a simple and scalable training solution to improve anti-G protection in fighter aviation.

MILITARY IMPACT

High-intensity conflicts require air combat training that exposes pilots to a high risk of A-LOC and G-LOC. Prevention relies mainly on perfectly executed AGSMs. The 5-year centrifuge training scheduled in the current NATO STANDARD AAMedP-1.13 can be complemented by squadron-based refresher training using the MAG TRAINER. The French Air and Space Force plans to deploy the MAG TRAINER in fighter bases and schools to improve AGSM training between 5-year centrifuge training sessions.

AUTHORS

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Thematic 18 :
Aerospace physiology

#46727905
Poster Presentation

In-Flight Exercise Guide for Fighter Pilots: A Feasible Tool to Reduce Musculoskeletal Disorders and Support Operational Performance

BACKGROUND
In-Flight Exercise Guide for Fighter Pilots: A Feasible Tool to Reduce Musculoskeletal Disorders and Support Operational Performance Background Fighter pilots are exposed to prolonged static postures in confined cockpits, repeated high G-force loads, and head-mounted equipment. These constraints contribute to a high prevalence of musculoskeletal disorders (MSDs), particularly cervical and lumbar pain, as well as increased risk of lower limb venous pooling. Current physical training strategies primarily target pre- and post-flight phases, leaving a gap during flight. No standardized in-cockpit exercise protocol currently exists for operational use.

METHODS
A practical exercise guide was developed based on consultation with fighter pilots and physical therapists. Exercises were selected according to feasibility within cockpit constraints, safety during flight operations, and targeting of commonly affected body regions. The guide consists of a structured full-body sequence, from distal to cervical regions, and is delivered in a short video format to enhance accessibility and compliance. This preliminary tool was reviewed by subject matter experts but has not yet been evaluated in a controlled study.

RESULTS
The guide includes a sequence of isometric contractions and active mobilizations that can be performed without additional equipment. Expert review supported the feasibility and operational compatibility of the proposed exercises within standard fighter cockpit environments. Informal pilot feedback suggested good acceptability and ease of use.

CONCLUSION
This in-flight exercise guide represents a novel, low-cost, and operationally compatible approach to mitigating flight-related musculoskeletal strain. Controlled evaluation with pre- and post-flight pain and performance measures is warranted.

MILITARY IMPACT
Musculoskeletal pain is a leading cause of temporary medical grounding among fighter pilots. Providing a practical in-flight exercise solution may reduce mission-related physical strain, help sustain cognitive and operational performance during high-intensity operations, and decrease long-term healthcare costs associated with MSDs. Keywords: fighter pilot, musculoskeletal disorders, in-flight exercise, cockpit, operational performance

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Thematic 18 : Aerospace physiology

#46789089
Poster Presentation

Thermal Performance of Graphene-Reinforced PVC for Spacesuit Liquid Cooling Garment Applications

BACKGROUND

During extravehicular activities, liquid cooling garments cool the astronauts by circulating water in tubes distributed over the body. Reducing the weight and enhancing thermal conductivity of the tubes are desired considering mass constraints and heat rejection requirements. Compared to PVC used in current LCGs, graphene-reinforced (GR) PVC offers higher thermal conductivity. This study compared the thermal performance of PVC and GR-PVC in a subscale LCG configuration and in human wear trials.

METHODS

A thermal contact resistance test apparatus was constructed to compare the contact resistance of garment swatches made of PVC and GR-PVC. The apparatus employed an Aluminum 6061 block instrumented with thermistors along its length to measure the axial temperature gradient. A hot plate beneath the Al block maintained a constant temperature of 50oC while the garment swatch placed on top was supplied with chilled water at 10oC. Heat transfer rate along the block and overall thermal resistance were calculated. For human wear trials, eight young males completed two cooling-garment conditions using PVC and GR-PVC tubing in a climate chamber.

RESULTS

GR-PVC had a 10.1% reduction in mass relative to the baseline PVC (15.8 g vs. 17.6 g per unit length). GR-PVC showed a higher heat transfer rate (36.5 ± 1.5W) and lower thermal resistance (1.007 ± 0.032 K/W) compared to the baseline PVC (32.6 ± 0.7W, 1.150 ± 0.021 K/W), resulting in a 12.1% improvement in heat transfer rate and a 12.4% reduction in thermal resistance. (The results from the human wear trials will be presented soon).

CONCLUSION

These findings demonstrate that GR-PVC can increase the overall heat rejection capability of the LCG while reducing the system weight. This suggests that GR-PVC tubes represent a promising material solution to meet the mass reduction and heat rejection requirements of spacesuits for extravehicular activities.

MILITARY IMPACT

Liquid cooling garments may also be applied in military operations, particularly in high-intensity missions where personnel must sustain performance under extreme thermal and metabolic loads while wearing heavy protective systems. Potential users include bomb disposal personnel and service members operating in harsh jungle or desert environments. Enhanced cooling efficiency combined with reduced weight is expected to mitigate overheating risk and thereby preserve cognitive and physical performance in military personnel.

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Thematic 18 : Aerospace physiology

#45966274
Poster Presentation

Changes in coordination motor skills between air force cadets and experienced military pilots during survival training

BACKGROUND
One of the more important training of military pilots is preparation to acting in isolation (SERE). The age of military pilots varies, on average they are 20-50 years old, hence the aim of the research was a comparative analysis of the impact of long-term survival training and sleep deprivation on selected coordination motor skills among air force cadets and experienced military pilots.

METHODS
16 military pilots took part in the training, 13 completed it. The average age of military pilots was 36±8.3 years; military service 17.3±8.8 years; BMI 25.6±2.2 kg/m² The second group consisted of 15 cadets: age 19.6±0.3 years; 1 year of study at the Military Aviation Academy; BMI 22.5±0.4 kg/m². The subjects took part in a 36-hour survival school training, during which they were deprived of sleep. Tests of coordination motor skills were carried out at the beginning of the training (M1) and immediately after the end (M2). The following tests / trials were carried out: • measurement of the ability to differentiate the strength of the forearm muscles, • motor adjustment (running tests), • the body balance disturbance tolerance skills (BBDTS).

RESULTS
Measurement of the ability to differentiate the strength of the forearm muscles [in N]: in both groups, a decrease in the maximum strength of the forearm muscles was found between M1 and M2 (respectively: cadets 791 and 701; military pilots 672 and 630). It was found that the lower ability to differentiate the strength of the forearm muscles in cadets compared to military pilots (cadets: M1: Err 50% 17±58; Err corr 23±40; M2: Err 50% 30±39; Err corr 28± 22; military pilots: M1: Err 50% 26±15; Err corr 11±9; M2: Err 50% 17±10; Err corr 7±5). Motor adjustment (running tests) [in m/s]: no statistically significant differences were found between cadets and military pilots in the 15m run, 3x5m run, 15 slalom run. The difference was found in the 15 m squat (all fours) run in M2 (cadets: M1: 3.21±0.4; M2: 3.19±0.4; military pilots: M1: 2.20±0.60; M2: 1.98±0.40). BBDTS (points): A greater deterioration in BBDTS was observed in cadets than in military pilots (cadets: M1: 3.2±2.2; M2: 5.8±3.11; military pilots: M1: 5.8±3.11; M2: 6.9±3.4). It should be emphasized that 3 military pilots did not complete the tests (motor adjustment and BBDTS) due to lower limb injuries.

CONCLUSION
Military pilots showed a better ability to differentiate the strength of the forearm muscles and BBDTS stability compared to the cadets. This is probably due to professional experience and special aviation training. Military pilots tolerated efforts related to speed and coordination much worse (15 m squat). They also tolerated training (injuries) much worse.

MILITARY IMPACT
Older military pilots are more likely to be injured during prolonged physical exertion in the field, so more attention should be paid to this element during military training.

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Lecture 2

Wednesday 17th June

Jason Lee

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Jason Lee directs the Heat Resilience and Performance Centre and co-chairs the Human Potential Translational Research Programme at the Yong Loo Lin School of Medicine, National University of Singapore. He studies the physiological demands associated with passive and exertional heat stress and how humans adapt to ensure optimum performance and survival. Jason completed his 12-year tenure at the DSO National Laboratories in 2018 by directing the Human Performance Programme in his final appointment. Tapping on his experience as a Commando Officer in the Singapore Armed Forces and domain knowledge, he serves in various national and international panels related to human performance and safety. A key outcome of his work is the formulation of a holistic heat management system. Jason was the past chair for the Scientific Committee on Thermal Factors at the International Commission on Occupational Health (2018 to 2024) and the Heat Stress Work Group at the Ministry of Manpower, Singapore (2019 to 2020). He currently co-chairs the Heat Injury Clinical Practice Guidelines at the Ministry of Health, Singapore. He is on the management committee at the WHO-WMO Global Heat Health Information Network (GHHIN) and leads the GHHIN Southeast Asia Hub to scale up efforts in managing the complex health risks posed by rising ambient temperatures. Jason serves on the Technology Advisory Panel for Temasek Trust and the Expert Advisory Group for the Rockefeller Foundation.

Climate Adaptation for the Warfighter: Building Heat-Resilient Training & Operational Capacity

As global warming intensifies, heat resilience must extend beyond preventing injuries and preserving endurance. Extreme heat erodes sleep, cognition, and decision-making. By applying heat as controlled eustress in training, forces build physiological resilience, accelerate adaptation, and weaponise thermal tolerance as a tactical advantage in future hot-zone operations.

Nathalie Pattyn

Ecole Royale Militaire

Nathalie Pattyn, MD, MPsy, MSc, PhD, has a mixed clinical, research and operational background. She has been deployed with special forces teams as a medical officer in the Middle East and the Sahel; and on numerous occasions as the sole physician to Antarctica stations. The longest of these Antarctic deployments lasted for 15 months, during which she served as the physician at the Halley VI station (British Antarctic Survey), while setting up a new Life Sciences lab for the European Space Agency. In all these deployments, she combined clinical work with research on human performance. She is still a practising emergency physician and flight surgeon. In 2010, she founded the first multidisciplinary research unit in the Royal Military Academy in Belgium, VIPER, with Professor Xavier Neyt, to promote a 360-degree approach to human performance by combining engineering, psychology and biomedical science. Their main research axes include remote health care; sleep and fatigue; and human performance in extreme environments, which led to the edition of the “Handbook of Mental Performance” (Routledge) in 2024. She is currently an Invited Researcher at the Université de Montréal (Centre d'études avancées en médecine du sommeil, Hôpital du Sacré-Coeur), beyond her usual academic appointment as an Associate Professor in Human Performance at the Royal Military Academy. She also serves as a Med Lt Col in the Belgian Defence (Medical Component)

Our current industrialized Western society has replaced collective ideals with individual goals. Achieving the best version of oneself has become paramount in this worldview. The economic boom in the service economy targeting health and well-being has translated to the niche of people needing to achieve exceptional performance.
Bluntly put: there is a lot of money to be made in convincing people they need whatever one sells to improve their performance. And high-performance environments are a nexus of this economy, as they are optimal testbeds, potential clients (albeit in a niche market), but above all, heavy-weight marketing arguments to sell a similar or downgraded version of whatever product or service to the general public.
One caveat to keep in mind when attempting to evaluate the cost/benefit balance of the implementation of a new technique, is that time is an extremely spare resource in high-performance environments. Whereas national health authorities may not feel it necessary to intervene in the marketing of seemingly harmless devices promoting performance enhancement, the fact that the use of such device (or techniques) in high-performance environments will be at the cost of a potentially beneficial approach is actually harming the performer. This is a major difference between high performers and a more general audience.
This keynote will provide an overview of current challenges and caveats when attempting to monitor, manage or improve mental performance in tactical environments.

Thematic 19 : Physical training for high-intensity conflicts

Salle Moebius - Mod: B. Nindl + H. Kyrolainen

ORAL PRESENTATIONS

Effect of cognitive-motor dual-task training on sustained attention performance and neuromuscular fatigue during incremental cycling in trained athletes

The Effectiveness of a 10-Week Concurrent Strength and Endurance Training Program on the Physical Readiness of Trained British Army Soldiers

The United States Army's Holistic Health and Fitness System: Preparation Now for High-Intensity Conflict through Optimization of Soldier Physical and Non-Physical Readiness

High-Intensity Functional Training Is More Efficient Than Traditional Physical Training In Improving Soldier Physical Fitness

Neuromuscular performance differences between 7-week summer and winter mountain leader courses at the U.S. Marine Corps Mountain Warfare Training Center

The United States Army's Holistic Health and Fitness System: From Brigade to Soldier, Quantifying Improved Individual-Level Soldier Readiness as Measured by Army Combat Fitness Test (ACFT) Performance

POSTER PRESENTATIONS

Acute Hematological Response to Military Physical Training - Operational Cross Training in Brazilian Army Soldiers

Optimising Warfighter Physical Readiness: A View from the Trenches

The effects of pre-induced respiratory muscle fatigue on load carriage exercise performance in Royal Marines Commandos

What is the benefit of high-intensity interval training in preparing military personnel for high-intensity combat? A 4 weeks study on 20 active subjects.

Recovery after an ultra-endurance race; introduction of 248, a new medical monitoring protocol.

Physical Activity and Sleep Durations During United Kingdom Initial Naval Training

Physical Activity Volume and Sleep Durations During Royal Marines Initial Military Training – An Observational Analysis of Injury Risk Factors

Cardiovascular Demands of Performing in a Military Marching Band

Ability-based physical training: An investigation into the efficacy of effort-based load carriage prescription

Interval Training Is Not The Be All And End All: Optimising Endurance Training Intensity Distribution For The Warfighter

Appropriateness, Relevance and Feasibility of an Olympic Weightlifting Educational Program in a Swedish Armed Forces Context

Thematic 19 : Physical training for high-intensity conflicts

#1000055
Oral Presentation

Effect of cognitive-motor dual-task training on sustained attention performance and neuromuscular fatigue during incremental cycling in trained athletes

BACKGROUND
Intense cognitive-motor dual-tasks (CMDTs) typically induce central nervous system fatigue and reduce cognitive performance, even in individuals with high fitness level. We aimed to explore the efficiency of CMDT training in preventing central fatigue and cognitive performance decline in such scenarios.

METHODS
Forty trained adults were randomly assigned to one of three high-intensity interval training (HIIT) groups (4-weeks, 2-sessions per week): cycling alone (HIITCTRL), cycling with cognitive training during low- (HIITDTL), or high-intensity intervals (HIITDTH). Each training session consisted in 4×6 min self-selected intervals based on perceived effort (3-min “very strong” 3-min “very low”). Before and after training, participants completed an incremental cycling cognitive test (ICCT) until reaching task-failure (TF). Sustained attention Mackworth score, knee-extensor neuromuscular peripheral and central indices (e.g. voluntary activation, VA), prefrontal cortex (PFC) oxygenation, cycling and mental perceived efforts were assessed at each stage. Data were interpolated at 20-40-60-80% relative to TF pre-training (TFPRE), analysed using repeated-measures analysis of variance and are presented with 95% confidence intervals (CI), and effect sizes (Cohen’s d).

RESULTS
All groups increased ICCT endurance time after training by 3.0±4.2 min (95%CI [2.4, 3.6]; d=0.69; P<0.001). After training, the Mackworth score increased at TFPRE by 11±2.1% (95%CI [2.1, 19]; d=0.72; P=0.003), alongside with similar PFC oxygenation patterns (P=0.13), whatever the group. Only HIITDTL and HIITDTH mitigated VA decline by 4.5±3.2% and 5.0±3.7% respectively after training at TFPRE (for HIITDTH: 95%CI [-9.9, -0.1]; d=0.24; P=0.035). Only HIITDTL and HIITDTH reduced mental effort by 14±8 a.u. and 19±12 a.u. respectively after training throughout the ICCT (for HIITDTH: 95%CI [-30, -8.3]; d=2.0; P<0.001).

CONCLUSION
Whereas a traditional HIIT programme was associated with improvements in sustained attention alongside gains in endurance performance, CMDT-specific training more effectively mitigated central fatigue and reduced perceived mental effort during challenging CMDT scenarios.

MILITARY IMPACT
Implementing CMDT-specific protocols in military training may enhance operational endurance by reducing perceived mental effort and protecting against central fatigue. both of which are critical for maintaining safety and minimising the risk of lethal outcomes in high-stress combat situations.

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Thematic 19 : Physical training for high-intensity conflicts

#46173502
Oral Presentation

The Effectiveness of a 10-Week Concurrent Strength and Endurance Training Program on the Physical Readiness of Trained British Army Soldiers

BACKGROUND
The aim of this study was to investigate the efficacy of a 10-week concurrent strength and endurance training programme in comparison to traditional military physical training practices on the physical readiness of trained British Army personnel.

METHODS
Forty-eight, fully trained British Army infantry soldiers (males: n = 45; females: n = 3) were randomly assigned into either an experimental or control group. Baseline and post-testing measures included body mass, standing broad jump, seated medicine ball throw, one-repetition maximum hex bar deadlift, 100-m shuttle run, pull-ups, and 2-km run. Participants in the experimental group followed a 10-week concurrent strength and endurance training programme based upon a block periodisation model whereas, participants in the control group completed a 10-week programme based upon traditional military physical training practices (i.e., circuit training, steady state running).

RESULTS
Results indicated a greater effect size (ES) in all measures in the experimental group when compared to the control group with a significant ($p < 0.001$) improvement observed in one repetition maximum hex bar deadlift and pull-up performance.

CONCLUSION
Findings from this study demonstrate that a concurrent training programme based upon a block periodisation model elicits superior improvements in certain components of physical when compared to traditional military physical training practices. However, data suggests that a greater frequency and/or volume of endurance training may be required to elicit improvements in aerobic capacity. As such, it is recommended that warfighters conduct at least two strength and two endurance training sessions per week in addition to occupational task specific training.

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Thematic 19 : Physical training for high-intensity conflicts

#46607092
Oral Presentation

The United States Army's Holistic Health and Fitness System: Preparation Now for High-Intensity Conflict through Optimization of Soldier Physical and Non-Physical Readiness

BACKGROUND
Rising rates of obesity and physical inactivity among American youth have created a national security crisis, with 77% of young adults (17–24) failing to meet military eligibility standards. Beyond recruitment, these factors lead to higher musculoskeletal injury rates, medical non-deployability, and increased healthcare costs for the United States (U.S.) Department of War. Health and fitness professionals are critical to reversing these trends and ensuring the long-term performance of Soldiers across their careers. The aim of this presentation is to underscore the relationship of public health trends and military readiness, highlighting the critical role of health and fitness professionals in the U.S. Army's Holistic Health and Fitness (H2F) System in optimizing Soldier performance.

METHODS
This presentation elucidates data from department-level reports and recently published studies, including injury rates, U.S. Army fitness test performance, and the impact of H2F intervention strategies on operational capability. Using a retrospective, cohort-based design data were analyzed from 100 matched Active-Duty Brigade Combat Teams (50 H2F-resourced; 50 control) between Fiscal Year (FY) 2019 and FY2024, representing nearly 2,000,000 soldier observations.

RESULTS
Utilization of H2F Performance Team (HPT) personnel, particularly in proactive musculoskeletal injury (MSKI) prevention and rapid rehabilitation, directly correlated with a reduction in MSKI referrals and a drop in substance abuse profiles. Furthermore, units with fully embedded HPTs demonstrated an increase in Army Combat Fitness Test (ACFT) pass rates, and higher expert-level marksmanship compared to non-embedded units. By shifting from traditional, centralized medical care to unit-embedded, preventive coaching, HPTs successfully reversed readiness disadvantages, effectively increasing the number of deployable Soldiers to the force. The analysis indicates that focused, evidence-informed fitness interventions reduce injury rates, and improve lethality and overall force readiness.

CONCLUSION
Health and fitness professionals in the H2F System are crucial in transforming the performance and readiness of the force. The findings support the ongoing Army-wide expansion of H2F, validating the HPT model as a critical, cost-effective tool for maintaining a lethal, resilient, and enduring force.

MILITARY IMPACT
This session will elucidate the intersection of public health trends and military readiness, focusing on the essential role of evidence-informed interventions in preparing personnel for high-intensity conflict. Authors will provide actionable, return on investment-focused solutions to improve soldier retention, health, and combat effectiveness in preparation for high-intensity conflicts.

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Thematic 19 : Physical training for high-intensity conflicts

#46703586
Oral Presentation

High-Intensity Functional Training Is More Efficient Than Traditional Physical Training In Improving Soldier Physical Fitness

BACKGROUND
High-intensity functional training (HIFT) has been proposed as an efficient way to improve soldier performance but specific research is limited. This study aimed to compare HIFT with traditional physical training (TRAD) of lower intensity and longer duration in novice Italian Alpine soldiers.

METHODS
152 soldiers (65 females) were stratified by gender and randomly assigned to two groups. The HIFT group (n=77) performed circuit training sessions combining high-intensity running with callisthenics. The TRAD group (n=75) performed sessions focused on either running or callisthenics. Both groups trained 4-5 times a week for 8 weeks. Physical fitness and mood were tested pre, mid and post the training program using the Royal Marines Advanced Personnel Fitness Assessment (RM-APFA) (2-minute push-ups, sit-ups, pull-ups and a multi-stage running test) and the Italian Mood Scale. Motivation related to exercise and fitness improvement expectation were assessed pre. Exercise enjoyment and perceived workload were assessed mid and post. At the end of each training session, soldiers were asked to rate session intensity on a 0-10 scale (sRPE) and training load (sRPE-TL) was calculated as sRPE x session duration (min). Training efficiency was calculated as: (pre-to-post change in the RM-APFA total score/total training duration over the 8 weeks) x 100.

RESULTS
18 soldiers were lost to follow-up with no significant difference between groups. No significant differences between groups were observed for fitness level, mood, motivation and expectation at baseline. Average session duration was significantly shorter in the HIFT (33±11min) compared to TRAD (53±10min; p<.001) whilst sRPE did not differ significantly (HIFT 5.4±1.2, TRAD 5.1±1.1; p<.068). As a result, sRPE-TL was significantly lower in HIFT (185±71 a.u.) compared to TRAD (275±75 a.u.; p<.001). Exercise enjoyment and perceived workload did not differ between groups. Mood assessment revealed increased Fatigue and decreased Vigor after 8 weeks of training in both groups (p<.05). All fitness variables significantly improved in both groups over the 8 weeks of training (time p<.001) with the sit-up score improving more in TRAD (group x time p<.016). However, training efficiency was significantly higher in the HIFT group (3.3±1.8) compared to the TRAD group (2.4±1.1) (p=.002). Among participants who completed the training programs, the median [IQR] of sessions missed due to injury or illness was 0 [3] in HIFT and 2 [5] in TRAD (p = .024).

CONCLUSION AND MILITARY IMPACT
In novice Italian Alpine soldiers, HIFT improved physical fitness with higher efficiency and fewer days lost due to injury/illness than TRAD. The time saved by adopting an HIFT program could be allocated to other activities, such as specific skill acquisition. Future studies should evaluate the effects of such a training strategy on the performance of occupational tasks rather than just standard fitness tests.

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Thematic 19 : Physical training for high-intensity conflicts

#46727329
Oral Presentation

Neuromuscular performance differences between 7-week summer and winter mountain leader courses at the U.S. Marine Corps Mountain Warfare Training Center

BACKGROUND
Neuromuscular performance and body composition changes between 7-week (35-day) mountain leader courses during the winter and summer at the U.S. Marine Corps Mountain Warfare Training Center (Bridgeport, CA) are rather unknown. The tactical skills of winter (WLC) focused on skiing (23/35 days), and summer (SLC) focused on running and climbing (25/35 days), which may differentially affect neuromuscular performance. This study assessed differences in body composition, isometric mid-thigh pull (IMTP), and countermovement jump (CMJ) kinetics and kinematic performance changes between courses (WLC vs. SLC).

METHODS
All methods were approved by the appropriate Institutional Review Boards. Testing was performed at week 1 (Wk1), 4 (Wk4), and 7 (Wk7) of WLC and SLC. A total of 56 male warfighters at Wk 1(WLC n=26, 25±3 years old, 177±8 cm in stature, 15±5% body fat; SLC n=30, 27±5 years old, 177±9 cm in stature, 14±3% body fat) participated. Body mass (kg) and skeletal muscle mass (kg) were assessed from bioelectrical impedance analysis. CMJ trials were done on dual force plates with a single-camera markerless motion-capture system to assess measures of relative peak power (W/kg), jump height (m), and take-off peak range of motion for knee flexors and hip flexors (º). Relative peak vertical force (N/kg) and absolute (N) were measured from the IMTP on dual-force plates. Two-way mixed-measures ANOVAs were used to examine the interaction between time and course (mean±sd, ηp2, α=0.05).

RESULTS
Significant interactions were observed for body mass (p<.001, ηp2=.195) and relative peak power (p=.016, ηp2=.125). WLC body mass (kg) was higher (p<.001, η2=0.803) at Wk1 (85±10) than at Wk4 (73±11, p<.001) and at Wk1 than at Wk7 (81±10, p<.001). WLC relative peak power (W/kg) was higher (p<.001, η2=.461) at Wk1 (48±7) compared to Wk4 (45±7, p<.001) and Wk1 compared to Wk7 (44±7, p<.001), with no differences at Wk4 and Wk7. A simple main effect of time for SLC relative peak power (W/kg) decreased (p=.027, η2=.227), but pairwise differences were not different. Decreased absolute vertical peak force (N) (p=.003, ηp2=.192) was observed. For SLC only, vertical peak force declined (p=.010, η2=.318) from Wk1 (3095 ± 728) to Wk7 (2832 ± 723, p=.030); but not Wk1 to Wk4 or Wk4 to Wk7. Hip flexion (º) was also significantly higher in SLC compared to WLC (p=.018, ηp2=.183) at Wk7 (p=.009). No other changes were significant.

CONCLUSION
Variations in physical intensity and biomechanical properties may tax the body differently depending on activities such as running and rock climbing in the summer vs. skiing in the winter. Hence, any changes observed should be attributed to the course skill demands.

MILITARY IMPACT
Mountain warfare training imposes seasonally distinct neuromuscular demands. Preparing for these courses in austere environmental conditions is paramount for optimizing tactical skill acquisition and preserving neuromuscular performance.

AUTHORS
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Thematic 19 : Physical training for high-intensity conflicts

#46638298
Oral Presentation

The United States Army's Holistic Health and Fitness System: From Brigade to Soldier, Quantifying Improved Individual-Level Soldier Readiness as Measured by Army Combat Fitness Test (ACFT) Performance

BACKGROUND

The United States Army initiated the Holistic Health and Fitness (H2F) System to optimize soldier fitness and readiness across five domains—physical, mental, nutritional, sleep, and spiritual—by embedding inter-disciplinary H2F Performance Teams (HPTs) within units and brigades. These HPTs include strength and conditioning coaches, athletic trainers, physical therapists, registered dietitians, occupational therapists, and cognitive performance specialists who work directly within the brigades to provide proactive education and training focused on performance enhancement and lethality to mitigate injuries and improve overall fitness and readiness. Current return-on-investment (ROI) collected, analyzed, and presented show lower rates of musculoskeletal injuries (MSKI), lower MSKI referral rates, higher fitness test pass rates, and fewer behavioral health challenges. Most existing assessments rely on group-aggregate brigade level comparisons limiting causal inference at the individual level. As the H2F System continues to scale across the force, more granular analyses are required to isolate its causal impact on individual performance while accounting for the group-aggregate confounding factors.

METHODS

In this presentation, we have included individual level longitudinal data from the USARIEM SPHERE database. To go beyond the descriptive comparisons and assess the causal impact of H2F on soldiers' ACFT score, a quasi-experimental difference-in-difference (DiD) regression analysis was utilized. This method was chosen to control the effect of non-randomized intervention, compositional differences and other confounding variables associated with H2F-resourced and non-resourced units. Parallel trend assumptions to validate a causal impact were tested to achieve true estimate of H2F's impact on ACFT scores.

RESULTS

The analysis revealed that H2F-resourced units improved the median ACFT score by 15.5 points ($p < 0.001$). Similar corresponding improvements were seen across each of the ACFT's six events, but most sustained gains were observed in strength, power and anaerobic outcomes which included improvements in the three-repetition maximum deadlift (+ 15.5 lbs.), hand-release pushup (+3 repetitions) and standing power throw (+0.3 feet) ($p < 0.001$ for all events). These results support the hypothesis that H2F-resourced units achieve significantly higher ACFT scores and sustain that outcome over time.

CONCLUSION

This study demonstrates the causal impact of the H2F System to the individual soldier's performance in addition to unit aggregate metrics. It reveals that the system has strengthened key areas of physical performance including strength, power and anaerobic capacities. It also demonstrates that a holistic multi-domain approach can successfully improve physical and combat readiness across large, multi-specialty military population.

MILITARY IMPACT

This study provides the Army leadership with actionable evidence of H2F System return-on-investment (ROI). This success also offers a scalable and transferable model for other organizations required to optimize human performance. The results offer justification for continued investment in H2F and demonstrate the system's capability to optimize and support the U.S. Army's long-term readiness.

AUTHORS

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Thematic 19 : Physical training for high-intensity conflicts

#1000051
Poster Presentation

Acute Hematological Response to Military Physical Training - Operational Cross Training in Brazilian Army Soldiers

BACKGROUND
Operational Cross Training (OC) is a military circuit physical training method that combines moderate to high-intensity aerobic and neuromuscular exercises. Intense exercise can promote transient hematological changes, resulting from modifications in plasma volume or exercise-induced hemolysis. Analysis of the red blood cell series in the blood count associated with haptoglobin dosage can contribute to a better understanding of these physiological responses.

METHODS
This quasi-experimental study with repeated measures included 28 Brazilian Army soldiers aged 18 to 26 years who underwent a session of the CO military physical training method. Venous blood samples were collected at the following time points: before (baseline) and immediately after the exercise for hematological parameters and also 24 hours after the session for haptoglobin measurement. Hematological parameters were analyzed, including hemoglobin, hematocrit, and red blood cell count, in addition to serum haptoglobin levels. Normality was confirmed using the Shapiro–Wilk test. Differences between baseline and post-exercise values were assessed using paired t-tests, while repeated measures ANOVA was applied to analyze haptoglobin levels, adopting a significance level of p<0,.05 and using Jamovi software (version 2.6.44).

RESULTS
A significant increase in hemoglobin, hematocrit, and red blood cell count levels was observed immediately after the training session. Red blood cell count increased from 4.94 ± 0.41 to 5.17 ± 0.39 $\times 10^6/\mu L$ ($p<0.001$), hemoglobin from 14.87 ± 1.04 to 15.60 ± 1.02 g/dL ($p<0.001$), and hematocrit from 43.23 ± 2.84 to 45.46 ± 2.80% ($p<0.001$). No significant changes were observed in serum haptoglobin levels across the analyzed time points ($p>0.05$).

CONCLUSION
A single session of Operational Cross Training induces acute hematological changes characterized by increases in red blood cell count, hemoglobin, and hematocrit, consistent with physiological responses to intense physical effort. These changes are likely driven by hemoconcentration due to plasma volume reduction and splenic contraction, which transiently elevates circulating erythrocytes and may enhance oxygen transport capacity. The absence of changes in haptoglobin suggests that these alterations are primarily related to plasma volume shifts rather than exercise-induced hemolysis. These findings support the physiological safety of this training method and provide relevant insights for monitoring training load and maintaining operational readiness in military personnel.

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Thematic 19 :
Physical training for high-intensity conflicts

#46173310
Poster Presentation

Optimising Warfighter Physical Readiness: A View from the Trenches

The aim of this session would be to provide an applied presentation which synthesises operational experience, institutional knowledge, and available peer-reviewed evidence to consider what is the optimal approach by which to physically prepare the warfighter for the demands of the contemporary military operational environment. Sub-topics covered within this presentation would include the importance of physical readiness, needs analysis, performance testing, periodisation, planning, and programming, the importance of developing fundamental movement skills, the use of concurrent strength and endurance training, load carriage conditioning, and the integration of military occupational task specific training. Finally, it will conclude with a series of pragmatic recommended strategies which could be applied to enhance warfighter physical readiness.

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Thematic 19 : Physical training for high-intensity conflicts

#46519575
Poster Presentation

The effects of pre-induced respiratory muscle fatigue on load carriage exercise performance in Royal Marines Commandos

BACKGROUND
Previous work has demonstrated that moderate intensity loaded marching induces Respiratory Muscle Fatigue (RMF). RMF can negatively affect subsequent exercise performance due to associated physiological (e.g. increased breathing frequency (bf), increased heart rate, blood flow redistribution) and perceptual (e.g. increased perception of whole-body effort, task difficulty and breathing exertion) changes. However, it was unclear whether the presence of RMF directly degrades subsequent military task performance. It was hypothesised that the best-effort time to complete a 4 km run whilst wearing military load carriage (LC4K) would be slower in the presence of pre-induced RMF.

METHODS
Twenty-three male serving Royal Marines Commandos from the Specialist Training Wing (age 23 ± 3 y [mean ± 1SD], body mass 81.4 ± 6.0 kg, stature 1.79 ± 0.06 m, employment in-service 77 ± 31 days, predicted $\dot{V}O_2max$ 53.8 mL·kg-1·min-1, PImax 153 cmH2O, PEmax 219 cmH2O) completed two counter-balanced trials ([1] RMF trial or [2] Sham-RMF trial), separated by a single day of rest. At the start of both trials, participants performed a marksmanship task using an indoor electronic firing range. Following the marksmanship task, participants completed either [1] a standardised protocol to induce RMF (resistance: 80 % PImax, bf 12 breaths·min-1, inspiratory duty cycle 0.6, duration up to 40 min) or [2] the Sham protocol (resistance 15 cmH2O (~10 % PImax), bf 12 breaths·min-1, duty cycle 0.6, duration 5 minutes), using a hand-held inspiratory muscle trainer (Classic model, POWERbreathe, H&B Ltd, UK). RMF was successfully induced in protocol [1] (Inspiratory Muscle Fatigue [IMF] 10 %; Expiratory Muscle Fatigue [EMF] 20 %; RMF 29 %) and avoided in the Sham protocol ([2]) (IMF <1 %; EMF 5 %; RMF 5 %). Following completion of either protocol, participants performed marksmanship tasks, before completing a LC4K (torso-borne-load 30.25 kg). A paired samples t-test was performed to compare performance between the two trials. Alpha was accepted as α=0.05.

RESULTS
RMF was present at the end of the LC4K in both test conditions. No statistically significant differences ($p>0.05$) were detected between conditions in the time to complete LC4K (Sham 25:47 min:s vs RMF 26:29 min:s; $t=-1.763$, $p=0.093$, $d=0.3$).

CONCLUSION
The high levels of aerobic fitness and respiratory muscle strength exhibited by Royal Marines Commandos did not prevent RMF from occurring during the LC4K. LC4K times were not affected by pre-induced RMF. The hypothesis is rejected.

MILITARY IMPACT
Military personnel with high aerobic fitness and strong respiratory muscles may be resilient to any negative effects of pre-induced RMF on load carriage best effort performance. It is unknown whether these findings translate to other job roles, with different baseline fitness requirements and/or weaker respiratory muscle strength. Future work should establish whether RMF is deleterious to military task performance in those roles

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Thematic 19 : Physical training for high-intensity conflicts

#46644244
Poster Presentation

What is the benefit of high-intensity interval training in preparing military personnel for high-intensity combat? A 4 weeks study on 20 active subjects.

BACKGROUND
Effective training for military personnel requires simultaneous development aerobic capacity, strength, and strength endurance.Improved aerobic capacity supports long-duration activities and improves adaptability to extreme environments, while strength and strength endurance enable combat actions, load handling and load carrying. Personnel must increase their physical readiness without significantly increasing training load, due to time constraints and risk of injury affecting their operational capacity. High-intensity interval training (HIIT) is a time-efficient training method known to improve aerobic capacity. However, non-metabolic muscular adaptations are limited. Eccentric exercise, such as downhill running, may increase other muscular adaptation notably strength. We therefore evaluated various physical performance parameters (endurance, fatigue, strength) after 4 weeks of short HIIT running sessions in athletic subjects, using concentric (CON) or eccentric (ECC) running.

METHODS
Participants (n = 10 per group) performed 12 HIIT sessions on a treadmill (3/W) at a +2% (CON) or -10% (ECC) incline. Sessions were 5 to 14 repetitions, with 1 minute at maximal aerobic speed (MAS), followed by 75 second rest. Before and after training, participants performed 2 aerobic tests (MAS, 4 km time trial), a fatigue test (RSA, repeated sprint ability), and a strength test (maximum voluntary isokinetic contraction [MVIC] of the knee extensors at 60°/s). This protocol was approved by a Human Protection Committee in 2017 (ID RCB: 2016-A01982-49). Data were analysed using a Student's t-test.

RESULTS
In the CON group, participants were 20.6±0.3 YO, 171.1±1.9 cm, 65.5±1.8 kg. MAS and 4 km TT improved significantly ($p < 0.05$). In the RSA test, mean and total time also improved ($p < 0.01$ and $p < 0.05$ respectively), as well as the fatigue index ($p < 0.05$). However, the MVIC showed a significant loss of force production ($p < 0.05$). The 10 subjects ECC were 22.3±0.6 YO, 175.7±2.2 cm, 68.3±2.7 kg.
MAS was unchanged, however 4km TT improved significantly ($p<0.05$). RSA results and MVIC were unchanged. These two groups are young amateur athletes, which could be found in an incumbent military population. Only 12 HIIT CON sessions are needed to develop aerobic capacity, which is particularly interesting in a military environment compared to continuous training. RSA is a useful physical ability in urban combat or assault phases. However, there is a significant decrease in strength, which could be related to overtraining or relative energy deficiency. Conversely, HIIT ECC preserves strength loss while maintaining aerobic capacity. The metabolic stress of ECC is probably not enough to full aerobic and metabolic gain, but the specific neuromuscular adaptations associated with muscle damage seem to be an interesting avenue for preserving strength.

CONCLUSION
HIIT can prepare soldiers for high-intensity combat with rapid gains in aerobic capacity with limited volume.

MILITARY IMPACT
ECC addition could help preserve strength and be complementary to specific strength training. It would now be interesting to test the combination of these modalities on a population of young, relatively sedentary recruits with a view to mass recruitment expected in major conflicts.

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Thematic 19 : Physical training for high-intensity conflicts

#46730837
Poster Presentation

Recovery after an ultra-endurance race; introduction of 248, a new medical monitoring protocol.

BACKGROUND
Many military operations resemble endurance events, carrying risks like rhabdomyolysis and kidney failure, which can be life-threatening. Recovery after ultra-endurance races is poorly understood, with no standard markers to assess it. Objective of our study: determine the kinetics of clinical signs and biomarkers during the recovery phase and develop a recovery strategy after ultra-endurance exercise.

METHODS
The study involved twelve athletes (6 men, 6 women) (IDRCB:2019-A02445-52). Participants underwent an ultraendurance exercise where they covered the maximum distance possible on a 1.5 km loop within 24 hours. Recovery was evaluated using biological measures (blood and urine samples) and physical assessments (muscle and joint pain). Blood samples measuring CPK and myoglobin were taken before the test, immediately after, and at 24 and 48 hours post-exercise. Urine samples were collected before testing, at the end of the exercise, and each morning during the first 8 days. Pain levels were assessed prior to the test, at its conclusion, and every morning for 15 days.

RESULTS
Rhabdomyolysis was severe (CPK: 53239 ± 63608 UI/L) at the end of the race. Two days after the race, blood markers of rhabdomyolysis and renal function returned to near-normal levels. Four days post-race, urine dipstick tests for hematuria and proteinuria were normalized. The assessment of joint and muscle pain suggests that full recovery after exercise takes about 8 days.

CONCLUSION
Our research introduces the first post-exercise recovery monitoring system for ultra-endurance sports, with the 2-4-8 framework. The first two days post-race are critical for muscle and kidney recovery, with urinary dipstick testing at four days serving as a key checkpoint. Eight days appear suitable for athletes to safely resume training. This protocol provides time-based benchmarks for physicians to monitor rhabdomyolysis and kidney health.

MILITARY IMPACT
Ultra-endurance exercise may affect soldiers' health. Implementing a comprehensive, multifaceted protocol to monitor their daily lives is essential.

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Thematic 19 : Physical training for high-intensity conflicts

#46751503
Poster Presentation

Physical Activity and Sleep Durations During United Kingdom Initial Naval Training

BACKGROUND
Royal Naval (RN) training supports the transition from civilian to sailor, providing naval personnel with the technical and physical capabilities required for seafaring roles. Musculoskeletal injuries (MSKI) account for 50% of the outflow from the Naval Service and are a considerable burden within Initial Naval Training (INT). Large volumes of high-intensity physical activity (PA), with insufficient opportunity for recovery (sleep), may contribute to injury risk and present a modifiable risk factor for MSKI mitigation. This study objectively quantified exposure to PA and sleep in RN recruits and Officer Cadets (OCs) to better understand injury risk and inform effective mitigations.

METHODS
Eighty-two participants (n 18 female) from Recruit and OC INT courses (n 39 Recruits; n 43 OCs) were monitored during Phase-1 (Recruits) or the first term (OCs) of their courses. A validated wrist-worn wearable device (GENEActiv) was used to quantify PA and sleep. Data were reported in 1-minute epochs of light, moderate (M), and vigorous (V) PA, with the moderate and vigorous threshold combined into one metric (MVPA). Sleep was also quantified using subjective questionnaires (Pittsburgh Sleep Quality Index). The study was approved by the Ministry of Defence Research Ethics Committee (1035/MODREC/20).

RESULTS
Mean PA data evidenced high volumes of weekday MVPA (Recruits: 464 ± 75 min/day; OCs: 324 ± 64 min/day). A lack of progression in volume and intensity was observed across the measurement period for both groups. The highest and lowest volumes of MVPA were noted in Week-4 (504 ± 143 min/day) and Week-1 (398 ± 69 min/day) in recruits, and Week-7 (435 ± 116 min/day) and Week-12 (220 ± 35 min/day) in OCs, respectively. Mean daily sleep quantity was low (Recruits: 323 ± 62 min/day; OCs: 365 ± 91 min/day), indicating limited opportunities for recovery. Subjective data had a small mean difference (28 ± 5 min/night overestimation in Recruits and -9 ± 26 underestimation in OCs), confirming the objectively measured poor sleep quality.

CONCLUSION
These data demonstrated that INT is associated with high volumes of PA and low volumes of sleep for Recruits and OCs. Recruits were exposed to ~2 hours more MVPA per day than OCs, which may reflect different training objectives. A review of training progression to promote a more gradual increase in PA volume, alongside adjustments to training practices to protect recovery opportunities and improve sleep hygiene, may enhance training outcomes and reduce MSKI risk. Furthermore, future work should aim to quantify and, where possible, address the factors contributing to poor sleep duration and quality.

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Thematic 19 : Physical training for high-intensity conflicts

#46761900
Poster Presentation

Physical Activity Volume and Sleep Durations During Royal Marines Initial Military Training – An Observational Analysis of Injury Risk Factors

BACKGROUND
Royal Marines (RM) training prepares civilians for arduous, frontline, amphibious infantry roles. The associated physiological and mechanical stress of training-related physical activity (PA) may drive positive physiological adaptations. However, large volumes of PA, particularly at higher intensities, may also increase injury risk. Moreover, sufficient sleep is fundamental for health, wellbeing and military performance, with insufficient sleep further increasing injury risk. This study quantified RM recruit exposure to PA and sleep to better understand potential injury risk factors.

METHODS
Between September 2020 and July 2022, 171 RM recruit participants wore a wrist-worn accelerometery device (GENEActiv) to quantify the durations (min) of moderate and vigorous physical activity (MVPA = when the sum of vector magnitude [SVM g-force] exceeds pre-defined, validated thresholds) and sleep. Heart rate monitors and sleep diaries were used to contextualise movement and sleep data, respectively. Descriptive statistics were generated on a daily and weekly basis and for specific periods of the 32-week training programme relevant to syllabus design. The study was approved by the Ministry of Defence Research Ethics Committee (1035/MODREC/20).

RESULTS
Recruits undertook (Mean ± SD) 388 ± 83 min of MVPA per day, with approximately 20% above the vigorous threshold. Week-by-week analysis showed MVPA to be highest in the initial and final weeks of training. Temporal analysis highlighted that ~32% of MVPA was undertaken between 18:01-05:59. Mean sleep durations per night were short (329 ± 109 min), with a strong correlation between objective and subjective measures of sleep (R2 = 0.68). A moderate negative correlation was found between MVPA and sleep (R2 = 0.4); for every 10-minute increase in MVPA, sleep duration decreased by ~7-min.

CONCLUSION
Aligned with previous military training literature, high volumes of MVPA were observed across RM training, with MVPA highest in the early and later weeks of training. Additionally, poor sleep patterns were observed across most weeks of RM training, with no measurable recovery post high-stress periods. Insufficient sleep is known to impair physical performance, limit adaptation and impair cognitive function, thus is likely to reduce RM training benefits. Modifying syllabus design could decrease unnecessary MVPA and increase sleep opportunities during RM training. Longitudinal monitoring would establish if such changes are sufficient to reduce training related injury risk.

MILITARY IMPACT
The study highlights the potential for improving the balance between PA and sleep in military training. This may optimise training performance, improve physical adaptation, and reduce injury risk. Further, adjusting training design may enhance recruit health, wellbeing, and ultimately operational readiness.

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Thematic 19 :
Physical training for high-intensity conflicts

#46785639
Poster Presentation

Cardiovascular Demands of Performing in a Military Marching Band

BACKGROUND
Military musicians routinely perform ceremonial duties involving prolonged marching while carrying and playing musical instruments. However, the physical demands associated with these performances are poorly understood. Band members may also be required to undertake operational roles in support of military units, where physical demands differ greatly. The extent to which routine duties prepare band members for operational roles is unclear. This study aimed to quantify the cardiovascular demands of military marching band performances and evaluate their relevance and contribution to maintaining operational fitness standards.

METHODS
Ninety-five members of the UK Royal Marines Band Service (29.1 ± 8.5 years) volunteered to participate. Participants wore heart rate (HR) monitors (Open Body Architecture Network, USARIEM) throughout seven performances lasting 60 – 195 min. Cardiovascular demand was assessed using mean and peak HR expressed as a percentage of age-predicted maximum heart rate (% HRM) and as a duration (mins) in five exercise intensity zones (e.g., Zone 1 [50 – 59 %] to Zone 5 [90 – 100 %]). Data were analysed across the duration of seven performances and are presented as a percentage of performance time. Differences in % HRM between instrument groups (Percussion n 8, Wind n 28, Brass n 46, Dual n 13) were assessed using a one-way ANOVA. This study was undertaken as part of a service evaluation under the MODREC direction for such work (JSP 536).

RESULTS
Mean HR across the performances was 107 ± 4 bpm (56 ± 2 % HRM). On average, 76 ± 11 % of time was spent in or below exercise Zone 1 and 24 ± 11 % in exercise Zone 2. Mean % HRM entered Zone 3 during one performance. Instrument group had no significant effect on % HRM ($p = 0.3$, $\omega^2 = 0.007$).

CONCLUSION
Performing in a military marching band imposes a low cardiovascular demand, with the majority of performance time spent at intensities below 60% HRM. Although peak HR occasionally entered moderate intensity zones, sustained periods of high cardiovascular strain were uncommon. These findings demonstrate that marching band duties alone are unlikely to provide a sufficient stimulus to improve or maintain aerobic fitness. Targeted physical training should be prioritised to ensure military musicians meet occupational demands and are appropriately prepared for operational roles.

MILITARY IMPACT
Marching band performances alone are unlikely to maintain operational levels of aerobic fitness, reinforcing the requirement for structured, task-specific physical training in military band units.

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Thematic 19 : Physical training for high-intensity conflicts

#46787189
Poster Presentation

Ability-based physical training: An investigation into the efficacy of effort-based load carriage prescription

BACKGROUND
Physical training in military settings is c typically delivered in large groups with little or no adjustment for individual fitness levels. This standardised approach to training delivery can result in varying physiological adaptations to everyone completing the training. Specifically, during Basic Training, research has demonstrated superior training adaptations in those with the lowest baseline fitness at the beginning of training whilst those individuals with the highest baseline fitness at entry experience a detraining effect. One approach to ensuring a suitable training stimuli is experienced by all could be the use of ability-based training programmes. Plausibly, this training approach could also reduce the risk of injury. Load carriage (LC) is a critical physical requirement within the military and therefore features considerably within military training. It is both a training modality and a role related task that individuals must be familiar and competent at completing. Utilising Rating of Perceived Exertion (RPE) as an exercise prescription method during LC activity could be one approach for individualising physical training, whilst developing role related competencies. However, no studies have addressed the efficacy of effort-based load carriage prescription. Therefore, the aim of this research project is to investigate the use of RPE as a tool for prescribing exercise intensity during a LC activity.

METHODS
Participants will be required to complete three experimental visits of identical design. The only exception will be the final visit where participants will complete a maximal exercise test at the end of the protocol. Following a warm-up and familiarisation, participants will complete the LC task twice on a motorised treadmill; first carrying 10 kg (weighted vest) and second carrying 20 kg (weighted vest and backpack). The LC task will consist of three, eight-minute RPE stages during which the participant will need to self-select a speed that matches the prescribed RPE value. The chosen RPE values are RPE 9 (very light), RPE 13 (somewhat hard), and RPE 15 (hard). Treadmill speed, heart rate and expired gas will be collected at each RPE stage. V̇O2max and gas exchange threshold (GET) will be obtained from the maximal exercise test. The primary dependant variable is the intraparticipant variation of speed at different RPE stages across the three visits; with the two LC conditions analysed separately. Secondary dependant variables of %V̇O2max, %GET and heart rate will be compared across visits. Bland Altman and equivalence testing will be used to compare experimental visits.

RESULTS
Data will be collected between February and May 2026.

MILITARY IMAPCT
Ability-based training may provide a method for ensuring individuals are provided with similar stimuli during training; thus, reducing the chance of maladaptation or responses to physical training. Herein we report the typical variance in performance (speed) and physiological responses (%V̇O2max, %GET and heart rate) to effort-based load carriage prescription, across two LC masses, allowing informed decisions to be made regarding the utility of this type of exercise prescription to military training staff

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Thematic 19 : Physical training for high-intensity conflicts

#46803923
Poster Presentation

Interval Training Is Not The Be All And End All: Optimising Endurance Training Intensity Distribution For The Warfighter

Military occupational tasks are extremely varied in nature and require the development of a broad spectrum of physical fitness characteristics. However, a considerable body of evidence suggests that a large aerobic capacity (i.e., VO2max) underpins performance in many criterion military occupational tasks such as a sustained heavy load carriage, casualty evacuation, obstacle crossing, and movement under fire. Furthermore, a higher aerobic capacity has been shown to enhance general health and wellbeing, potentially infer greater physiological and psychological resilience to the stress of combat (i.e., fatigue, sleep deprivation, sub-optimal nutrition, exposure to adverse environmental conditions), and enhance cognitive capability. Whilst the inclusion of strength training has enhanced some warfighter occupational tasks, measures of endurance capacity have remained relatively consistent with anecdotal reports from military training staff suggesting that they may have even regressed, which in turn has led to a reduction in performance of certain essential military tasks such as load carriage. Taken collectively these observations suggest that the adoption of contemporary evidence led strength and conditioning practices has been only partially effective and that the replacement of high-volume, low-intensity (HVLIT) endurance training with just high-intensity interval training (HIIT) may be detrimental to the development of overall warfighter physical readiness.

In other words, has the pendulum towards the concept of the anaerobic battlefield swung too far and does military physical training (PT) need to adopt a more balanced, holistic approach towards the development of warfighter physical readiness? Whilst the use of periodisation, planning, and programming strategies to guide the prescription of strength training within military populations has been well reported in the literature little has been stated in regard to optimising the prescription of endurance training. Given the importance of aerobic capacitU arguably a more nuanced approach towards prescription of endurance training as part of a holistic concurrent training program is required.

Therefore, this begs the question, how do endurance athletes train? And how can this knowledge potentially be integrated within a military PT setting to enhance warfighter occupational task performance?

To that end, the following presentation will aim to firstly review the importance of developing aerobic capacity for the warfighter, consider the key determinants of endurance performance, and then argue that the adoption of either a polarised or pyramidal training intensity distribution (TID) model as used by successful endurance athletes may help to optimise the development of warfighter physical readiness, psychological robustness, and cognitive performance.

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Thematic 19 : Physical training for high-intensity conflicts

#46808556
Poster Presentation

Appropriateness, Relevance and Feasibility of an Olympic Weightlifting Educational Program in a Swedish Armed Forces Context

BACKGROUND
Research has identified lifting and carrying as criterion tasks and expected to be carried out by forces members in all areas of operations. Olympic Weightlifting (OW) can allocate biomechanical similarities to lifting while performing military tasks. OW has indicated a good effect on development of power output, essential to several critical military tasks in operational environments. The Swedish Olympic Weightlifting Federation (SOWF) offers a standardized Education Program (EP) for Olympic Weightlifting that could potentially be implemented in the SwAF. It has not earlier been explored if an EP for complex lifting is possible to apply in a military setting. Before attempting to implement or study effectiveness of the program itself, consulting users and stakeholders about appropriateness, relevance and feasibility is vital to take the military context into consideration. The aim of this study was to explore the perceived acceptance and feasibility of taking an existing, quality assured EP for complex lifting in a SwAF context.

METHOD
The study used a cross-sectional design to evaluate appropriateness, relevance and feasibility of an Olympic Weightlifting EP (from the SOWF) by a questionnaire to users (n= 69), i.e soldiers and enablers/facilitators (n=49), i.e Platoon Commanders and support personnel, from 8 different SwAF regiments. The questionnaire included individual factors, items for assessment of plausibility, priority, appropriateness, relevance and feasibility of the overall content of the EP, and items for assessment of appropriateness, relevance and feasibility on four different alternatives: Education on base (alt.1 and 2) or off base (at a local SOWF certified club venue) (alt. 3 and 4) and either two days education followed by 8 sessions to be conducted individually (alt. 1, 3) or two education sessions followed by 8 group sessions with instructor (alt. 2, 4). Answers were reported as proportions of positive response with corresponding 95% CI. Comparison between the four course alternatives and potential divergent views between users and enablers/facilitators were analyzed with chi-square and fisher exact statistics.

RESULTS
The EP was perceived as plausible (87%, 95% CI 80-92), prioritized (77%, 95% CI 69-84), appropriate (95%, 95% CI 89-98), relevant (88%, 95% CI 81-93) and feasible (75%, 95% CI 66-82), with no significant divergent views between users and enablers/facilitators. The on-base course alternatives were deemed the most appropriate and the on-base short course the most feasible. A larger proportion of users compared to enablers/facilitators also considered the off-base alternatives as appropriate and relevant.

CONCLUSION
This study indicates that this EP is considered acceptable and feasible, by both users and enablers/facilitators, to conduct in a military setting, under the condition that one of the on-base alternatives is used. Identified challenges lie in accessing time to allow a 10-week EP, and infrastructure for conducting the training. Considering these results, it is worth further exploring considering compliance, through a pilot study, and furthermore also the effect of the EP.

MILITARY IMPACT
These results will be used to guide implementation of this EP, and possibly other methods for effective and relevant training to enhance soldiers' capacities and, in extension, solving of military tasks during training and operations.

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Thematic 20 : Nutrition in hot or cold environment

Le Grand Salon - Mod: K. Charlot + E. Howard

ORAL PRESENTATIONS

Comparison of the efficiency of different nutritional strategies on spontaneous energy intake and body mass loss during 15-day military expeditions in Greenland in extreme cold

Field-Feeding Capabilities for Cold Weather and Arctic Feeding F

Energy intake during passive acute cold and heat exposure: influence of meal congruency with Food Reward

Energy Intake During an Arduous Military Exercise in an Extreme Cold Environment

Physiological and Metabolic Responses to Strenuous Arctic Military Training in Males and Females

Daily energy intake during a 100-day military winter exercise: longitudinal outcomes in body composition, strength, and physical performance

Slush but Not Slush–Glycerol Lowers Core Temperature During Military-Relevant Activity

POSTER PRESENTATIONS

Knowledge and behaviours regarding hydration among French military personnel deployed to hot environments: how can we improve the consumption of military sports drinks in combat rations?

Development of an individualized and strategic nutritional approach for soldiers during military expeditions in extreme cold: A multi-year field model in Greenland.

Changes in iron and vitamin D status in a small sample of male rangers

Thematic 20 : Nutrition in hot or cold environments

#46580313
Oral Presentation

Comparison of the efficiency of different nutritional strategies on spontaneous energy intake and body mass loss during 15-day military expeditions in Greenland in extreme cold

BACKGROUND
Reaching adequate energy intake (EI) and avoiding body mass loss (BML) during military trainings in extreme cold conditions represent a difficult challenge for numerous reasons (logistics, difficulties to prepare and eat foods, increase in energy demands, ...). The identification of the most efficient strategy is of great importance for soldiers training during several days.

METHODS
Four different rations were proposed to four different groups of 12 French soldiers realizing 15-day expeditions in Greenland (-35 to -5°C). All rations were built using freeze-dried and ready-to-eat foods that were already validated for these environments. Two groups were served fixed rations: one small ration (S - 3700 kcal, 831 g) and one large ration (L - 4700 kcal, 1099 g). One group was served a scalable ration (SL - 3700 during the first 10 days and then 4700 kcal; 859 g). The last one was adapted to their individual estimated energy needs (IND – ~4500 kcal, 1034 g). EI was accurately calculated using pre-filled diaries with all foods and subjective hunger scores using visual analogue scales. Body mass was measured just before and the day after the end of the expedition in the morning.

RESULTS
Body mass was significantly lower after the expeditions than before (from -4.2 ± 1.9 kg in S [p<0.001] to -0.9 ± 1.1 kg in L [p=0.021]) with the exception of IND (-1.1 ± 1.8 kg; p=0.091). BML was found to be larger in S than the others (p<0.020). Mean EI was slightly lower in S (3346 ± 503 kcal) than L (3908 ± 476 kcal; p = 0.083) and IND (3966 ± 754 kcal, p=0.062) but similar to SL (3470 ± 379 kcal). However, energy balance was lower in L (-226 ± 448 kcal) and IND (-169 ± 447 kcal) than S (-885 ± 580 kcal) and SL (-893 ± 580 kcal). Interestingly, EI expressed in the portion of the ration that was consumed was similar (S: 91.8 ± 13.8 %, SL: 89.3 ± 9.9 %, L: 83.0 ± 10.1 % and IND: 86.9 ± 12.2 %). Hunger scores increased during the last third of the expeditions with the L ration, while they were maintained with the IND ration.

CONCLUSION
The overall energy content of the ration during 15-day expeditions in the cold positively impacts EI and BML. A progressive solution (SL) had a very limited effect on EI but was able to reduce BML. Large rations adapted to their estimated needs (IND) seems to induce the same positive effects as the fixed large rations (L) with lower overall load carriage. Finally, regardless of the energy content and the observed body mass loss, soldiers kept leaving aside a small but significant part of the ration (8-17%), indicating that they may scale their food intake to the size of the available rations.

MILITARY IMPACT
The proposition of a large ration composed of foods adapted to the cold climate and with a portion of free choices allowing the estimated individual energy expenditure to be reached seems efficient to induce optimal EI and limit BML in reducing load carriage, especially for the soldiers with lower energy needs.

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Thematic 20 :
Nutrition in hot or cold environments

#46708233
Oral Presentation

Field-Feeding Capabilities for Cold Weather and Arctic Feeding

BACKGROUND

Cold weather operations (CWO; ≤8°C) present distinct physiological challenges for military personnel to perform optimally. During CWO, energy expenditure is typically elevated due to high levels of physical activity, snow, challenging terrain, and specialty equipment and garment, while energy intake (EI) is inadequate due to limited food availability, suppressed appetite, restricted time, and logistical challenges. Hydration status is also impaired during CWO due to both reduced fluid intake and increased losses, resulting in chronic hypohydration and/or dehydration. The aim of this presentation is to provide a comprehensive overview of nutritional and hydration considerations for military personnel during CWO.

METHODS

A systematic search to identify peer-reviewed research articles was conducted in PubMed using Medical Subject Headings when available, with exceptions noted. Search criteria included “Military Personnel” OR “Military” OR “Service Member” OR “Tactical Athlete” AND “Cold Weather Operations” OR “Cold Weather” OR “Cold Environment” OR “Extreme Cold Weather.”

RESULTS

Military guidelines for EI range from 9 to 25 MJ·d-1 (2,100 to ~5975 kcal·d-1) or approximately 30 to 77 kcal·kg body weight(BW)-1·d-1; however, there are no specific guidelines for CWO in military nutrition policy except for recognition of need for greater EI. Total energy expenditure (TEE) estimates during CWO are ~15 to 26 MJ·d-1 (3,529 to 6,149 kcal·d-1) or 44 to 74 kcal·kg BW-1·d-1, with EI consistently reported to be lower than TEE, resulting in a negative energy balance (EB; EB = EI - TEE) estimated between approximately -4 to -11 MJ·d-1 (-1,044 to -2539 kcal·d-1) or -13 to 27 kcal·kg BW-1·d-1. Factors such as time, mission tasks, situation, food choices and availability, and weight all contribute to inadequate EI. Manipulating dietary macronutrient composition has been explored as a strategy to improve energy status, but no specific guidelines for CWO have been determined.

Reported dietary carbohydrate (CHO) intake in CWO is at the low end of recommendations (3 to 4 g/kg BW), dietary protein intake has varied (1.2 to2.9 g·kg BW-1·d-1), and fat intake (on a gram basis; 35% of kcal) is likely in line with guidelines given the state of negative EB and decreased intake of CHO and protein during CWO. No specific guidelines have been established for micronutrients during CWO. While it has been acknowledged that fluid needs and risk of dehydration are greater during CWO, due to increased respiratory water loss, diuresis, and energy expenditure, requirements are not well defined, with general recommendations of 3 to 6 L·d-1, depending on activity level. Other factors that may affect EI during CWO include food availability (e.g., field stripping rations, need of water, field cooking options), food packaging (e.g., durable, waterproof), logistical constraints (e.g., food freezing), and low appetite/desire to eat.

CONCLUSION AND MILITARY IMPACT

An increase in military strategic focus and more frequent deployments in the Arctic necessitate a better understanding of how nutrition and hydration status influence operational readiness and performance of military personnel during CWO.

AUTHORS

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Thematic 20 : Nutrition in hot or cold environments

#46749555
Oral Presentation

Energy intake during passive acute cold and heat exposure: influence of meal congruency with Food Reward

BACKGROUND

Military personnel and athletes are characterised by their high levels of energy expenditure (EE). They are, moreover, required to live, train, and perform under extreme heat and cold environments which could exacerbate the EE by the increased thermoregulatory demands. Moreover, thermal exposures may also directly impact the energy intake (EI) by modulating appetite. These phenomena could lead to an energy deficit which impairs physiological function and health. One way to mitigate is to investigate the effects of meal congruency based on the temperature of serving of foods on EI. Indeed, food reward for cold/hot foods is strongly impacted by thermal exposure (appeal for cold foods in hot conditions and for warm foods in cold conditions). We therefore wanted to compare the modification of EI during a meal served in a cold or hot environment to a thermoneutral condition between a group only receiving a cold meal and a group receiving a warm meal.

METHOD

Two groups of 15 subjects were exposed during 6 h to cold (15°C), thermoneutral (25°C) and heat (35°C) conditions in a bioclimatic chamber. At 01:00 pm (4:30 after the beginning of thermal exposures), a test meal consisting of an ad libitum main dish was served. One group was served a cold meal (CM) while the other one was served a warm meal (WM). Food reward was measured before lunch using Leeds food preference questionnaire (LFPQ), subjective appetite was regularly assessed using visual analogue scales, and skin and rectal temperatures were recorded continuously.

RESULTS

As expected, appeal for cold foods increased in the heat condition ($p < 0.001$) and appeal for warm foods increased in the cold condition ($p < 0.001$). Moreover, the composite appetite score was decreased in the 90 min before the meal only in the heat condition ($p < 0.001$) but remained unchanged in the cold condition compared to the thermoneutral one. In agreement with the literature, EI was lower in the heat condition ($p = 0.006$) and higher in the cold condition ($p = 0.015$) compared to the thermoneutral one when all participants were merged in one group..

However, the heat-induced decrease in EI was only observable in the WM group (incongruent) ($p < 0.001$) but remained unchanged in the CM group (congruent). In the cold condition, no specific effect of the congruency of the meal was noted. Thus, meal congruency appeared to mitigate the heat-induced reduction in appetite (i.e., no energy deficit despite lower subjective appetite) but had no specific effect in the cold, in which EI was increased in both groups despite no increase in subjective appetite.

CONCLUSION

Thermal exposures differentially altered EI and subjective appetite. All participants considered, subjective appetite and EI were decreased in the heat conditions. In the cold, EI was increased despite unmodified subjective appetite. However, providing a congruent meal based on the thermal exposures-induced modifications in food reward was found efficient only in the heat condition.

MILITARY IMPACT

Offering congruent foods (i.e., cold foods) to soldiers exposed to hot conditions may represent an efficient strategy to limit energy deficit in an environment well known for its anorexigenic effect. The present results also refine the known effects of cold on EI, suggesting that difficulty to avoid energy deficit is mainly driven by the high EE and the technical constraints rather than by the appetite and meal incongruency

AUTHORS

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Thematic 20 :
Nutrition in hot or cold environments

#46757227
Oral Presentation

Energy Intake During an Arduous Military Exercise in an Extreme Cold Environment

BACKGROUND

Arduous military operations in extreme cold environments present one of the most nutritionally challenging contexts, often characterised by significant energy deficits. Previous research demonstrates that prolonged exposure to a negative energy balance is likely to result in declines to health and performance markers. Therefore, ensuring sufficient nutritional intake during arduous operational activity in the extreme cold requires consideration. This study aimed to quantify and explore factors that may influence energy intake during demanding military exercises in the extreme cold.

METHODS

Thirty-six United Kingdom Royal Marines, across three Units, volunteered to participate (mean ± SD: age 28 ± 4 years; height 1.79 ± 0.06 m; body weight 83.7 ± 7.5 kg). Participants were monitored during cold weather military training exercises each four to five days in duration (0 to -20 °C). Personnel were provided with ~5300 kcal·day-1 through operational ration packs. Energy and macronutrient data were provided by the manufacturers. Participants were instructed not to self-supplement during the exercise. Ration discards were collected at the end of the exercises to estimate energy intake. User acceptability, practicality, and perceptions of satiety and fatigue were assessed using a bespoke online survey (LimeSurvey, GmbH). The study was approved by the Ministry of Defence Research Ethics Committee (2337/MODREC/24).

RESULTS

Mean ± SD daily energy intake during the exercises was 2736 ± 756 kcal·day-1, equating to ~52 % of provided energy (range: 1552 to 4376 kcal·day1). Fat intake contributed over 40 % of the total energy intake. Multiple factors influencing energy intake were reported pertaining to logistical limitations (e.g. cooking and food preparation), suitability and/or palatability of food items in extreme cold (e.g. freezing of products), limited appetite, and perceptions of adequate fuelling despite under-consumption.

CONCLUSION

Military operations and exercises in the extreme cold require high energy intakes to meet the significant energy demands caused by the environment, terrain and the activity undertaken. Despite provision of ~5300 kcal·day-1, on average participants consumed only ~52 % of this energy. However large inter-individual variability was observed, with some participants consuming over 80 % of provision. The cause of the low mean energy intake was multifactorial, thus further work must investigate reducing possible barriers. Practitioners and Chain of Command should focus on improving education surrounding energy needs and the effects of negative energy balance, whilst research should explore ways to mitigate these.

MILITARY IMPACT

With increasing focus towards operating at-reach in extreme cold environments, failure to consume sufficient energy has the potential to impact operational effectiveness. Further, exposure to severe negative energy balance can impact health, and therefore retention, of military personnel.

AUTHORS

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Thematic 20 : Nutrition in hot or cold environments

#46768213
Oral Presentation

Physiological and Metabolic Responses to Strenuous Arctic Military Training in Males and Females

BACKGROUND
Arctic military operations impose high physiological and metabolic demands. Understanding the magnitude of these stressors and their impact on males and females is essential for optimizing performance. This study aimed to characterize external workload and the resulting physiological and metabolic responses to Arctic military training in males and females.

METHODS
Twenty-four male and twelve female conscripts completed this observational longitudinal field study consisting of 8 days of Arctic field training (−9.3°C to 7.1°C) with standard rations (3900 kcal) provided daily. External workload was estimated using the weight of carried equipment (excluding food, water, ammunition, and communications equipment) measured before the exercise, and daily accelerometer step count. Total energy expenditure (TEE) from doubly labeled water, energy intake (EI) from wrapper/food-waste collection, and energy balance (EB=TEE−EI) were assessed daily. Body composition (InBody) and lower-body power (vertical jump) were assessed before (PRE) and after (POST) the exercise. Fat oxidation was calculated as Δfat mass (FM)/initial dry lean mass (DLM). Males and females were compared using unpaired t-tests, and time-by-sex effects were tested with linear mixed-models and Bonferroni-adjusted pairwise comparisons.

RESULTS
Males and females had similar daily step count (23,515 ± 1873 vs. 23,882 ± 2302 steps·d-1; P=.64) and absolute external load (47.6 ± 2.1 vs. 47.6 ± 2.6 kg; P=.98), but males carried lower relative load than females (61 ± 6 vs. 75 ± 5 % body mass; P<.001). Males had higher absolute TEE (5557 ± 484 vs. 4428 ± 456 kcal·d-1; P<.001) and EI (3620 ± 346 vs. 2818 ± 260 kcal·d-1; P<.001), and lower EB (−1907 ± 394 vs. −1610 ± 407 kcal·d-1; P=.046) than females, but there were no differences when adjusting for body mass (EI: 46.4 ± 5.2 vs. 44.3 ± 2.5 kcal·kg-1·d-1; TEE: 71.4 ± 6.4 vs. 69.6 ± 4.9 kcal·kg-1·d-1; EB: −34 ± 5 vs. −36 ± 6 kcal·kg-1·d-1; P >.05). Changes in body mass (−3.0 ± 0.8 vs. −2.4 ± 0.5 kg), total body water (−0.1 ± 0.8 vs. 0.5 ± 0.5 kg) and DLM (−0.3 ± 1.1 vs. 0.6 ± 0.7 kg) were different (P<.05) in males and females. Loss of absolute FM was similar (−2.7 ± 0.8 vs. −3.0 ± 0.6 kg; P=.30), but fat oxidation was lower in males compared with females (−0.14 ± 0.04 vs. −0.22 ± 0.4 Δfat·DLM-1 kg; P <.001). Lower-body power declined similarly in males and females (−145 ± 149 vs. −82 ± 97 W; P=.20).

CONCLUSION
Despite operating under higher relative external loads, females exhibited similar energy deficits (34%) and greater fat oxidation compared with males. The loss of lower-body power was similar in males and females, suggesting relative external load and substrate utilization were not primary drivers of performance declines with Arctic training.

MILITARY IMPACT
Similar declines in lower-body power suggest performance-maintenance strategies do not need to differ by sex during Arctic training with moderate (<40%) energy deficits.

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Thematic 20 : Nutrition in hot or cold environments

#46775688
Oral Presentation

Daily energy intake during a 100-day military winter exercise: longitudinal outcomes in body composition, strength, and physical performance

BACKGROUND
Cold weather operations are demanding, and maintaining energy balance is essential for sustaining operational capability. Large energy deficits have been reported in short (≤14 day) winter field exercises. This study aimed to measure daily dietary energy and macronutrient intake during a 100-day military winter exercise and its parallel longitudinal outcomes in body composition, strength, and physical performance.

METHODS
Thirteen male professional soldiers (25 ± 3 year; 84.8 ± 6.9 kg; 14.8 ± 2.3 % body fat; $\dot{V}O_2$max 58.3 ± 3.3 mL·kg-1·min-1) completed a 100-day winter exercise in the Arctic. The deployment was largely unsupported, except for a single food resupply on day 60. The study used a prospective observational longitudinal field design. Daily food intake was self-reported using a paper-based daily questionnaire. Body composition assessed using bioelectrical impedance analysis, and one-repetition maximum (1RM) strength was assessed pre-deployment (PRE), mid-exercise (MID), and post-exercise (POST). Incremental loaded marching capacity test (MCT) and maximal oxygen consumption ($\dot{V}O_2$max) were measured at PRE and POST. Period-average daily energy expenditure was estimated by adjusting mean energy intake for changes in body composition from PRE to POST. One-way repeated measures ANOVA was used to test changes in strength and body composition over time. A significant result was followed up using pairwise comparisons with Bonferroni adjustment. Paired t-test was used to test for differences in $\dot{V}O_2$max and MCT between PRE and POST.

RESULTS
Average dietary energy intake was 3668 ± 537 kcal·day-1, with 35 ± 4 % of energy from carbohydrates and 51 ± 5 % from fat; protein intake was 1.3 ± 0.1 g·kg-1·day-1. MCT and $\dot{V}O_2$max showed no significant changes from PRE to POST ($p > 0.05$). No significant changes were observed over time in 1RM squat, bench press, deadlift and weighted chin-up (all $p > 0.05$). Fat mass declined significantly across all time points, with a reduction of 1.9 kg from PRE to MID (95% CI 0.7 to 3.0; $p = 0.002$) and 1.5 kg from MID to POST (95% CI 0.5 to 2.5; $p = 0.003$). In total, this corresponded to a mean reduction of 3.4 kg (95% CI 2.0 to 4.9; $p < 0.001$). The period-average daily energy deficit was estimated at 250 ± 145 kcal·day-1.

CONCLUSION
Daily energy and macronutrient intake appeared sufficient to maintain performance throughout the 100-day exercise. Changes in body composition were primarily driven by reductions in fat mass, consistent in magnitude with previous military field studies despite the substantially longer duration of the present exercise.

MILITARY IMPACT
In cold and logistically demanding environments, ensuring adequate total energy intake may help sustain physical performance during prolonged operations.

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Thematic 20 : Nutrition in hot or cold environments

#46779907
Oral Presentation

Slush but Not Slush–Glycerol Lowers Core Temperature During Military-Relevant Activity

BACKGROUND
Military personnel are at risk of heat stress and heat-related illness during operations in hot environments due to the combined effects of environmental conditions, prolonged and intense physical activity, and protective clothing and equipment. Effective thermoregulation is critical for sustained performance and safeguarding soldier health during prolonged activity in the heat. Cooling strategies such as slush drinks and glycerol may be effective countermeasures to reduce these thermal risks by lowering core temperature and improving fluid retention. This study investigated whether slush and glycerol have a synergistic effect in reducing thermal strain.

METHODS
Eleven healthy male participants completed a randomized crossover study with three conditions: an isotonic drink (33 °C), a slush drink (0 °C), and a glycerol-containing slush drink (0 °C). The isotonic beverage was the standard Dutch Defence rations product, providing 17.5 g of carbohydrates and 0.19 g of salt per 250 ml. Participants consumed the isotonic drink at 7 g/kg body weight, while glycerol was administered at 1.2 g/kg body weight. All test beverages were ingested 30 minutes prior a treadmill march protocol consisting of three 50 minute walking bouts separated by 10 minute rest periods. Walking speed was individualized to achieve a metabolic power of 6 W/kg. Core temperature, skin temperature, and heart rate were measured continuously. The Greenhouse–Geisser correction was used when sphericity was violated. Condition and time effects were analyzed with a two-way repeated-measures ANOVA; when distributional assumptions were not met, Friedman tests were applied. Post hoc comparisons used Bonferroni correction. The significance level for all statistical tests was set at $\alpha = 0.05$.

RESULTS
The slush–glycerol condition resulted in a higher core temperature (37.85±0.51˚C) compared to the slush condition (37.57±0.38˚C, p=0.003), but not the control condition (37.65±0.44, p=0.097). The slush-glycerol condition also resulted in an elevated hear rate (122±13) compared to the slush condition (113±10, p=0.005), but not the control condition (119±15, p=1.3). Skin temperature was highest in the slush–glycerol condition (35.9 ± 0.50 °C), compared to both the slush condition (35.7 ± 0.50 °C; trend toward significance, p = 0.056) and the isotonic condition (35.6 ± 0.54 °C; significantly lower, p = 0.006).

CONCLUSION
Pre-cooling with a slush drink reduces thermal and cardiovascular strain during a military-relevant activity. Interestingly, adding glycerol increased core temperature and heart rate, suggesting that adding glycerol does not have added benefit during sustained military performance in the heat.

MILITARY IMPACT
Overheating is a persistent risk in military operations, underscoring the need for effective cooling strategies. This and other studies show that slush may serve as a practical heat mitigation method for soldiers. However, adding glycerol negated these benefits and increased physiological strain, indicating that glycerol should not be included in pre-cooling protocols.

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Thematic 20 : Nutrition in hot or cold environments

#46643820
Poster Presentation

Knowledge and behaviours regarding hydration among French military personnel deployed to hot environments: how can we improve the consumption of military sports drinks in combat rations?

BACKGROUND

Hydration is essential for military personnel to perform effectively and safely in a hot environment. Dehydration limits thermoregulatory capacity and is a risk factor for heatstroke and other complications (renal colic). Hyperhydration via hyponatremia can also cause fatal accidents. In order to improve the hydration behaviour of soldiers deployed to hot environments, it was necessary to describe their knowledge and practices in order to identify weaknesses.

METHODS

A questionnaire consisting of 68 items (biographical, knowledge, behaviours) included 464 military personnel deployed to the Sahel and the United Arab Emirates in early 2021. Statistical analysis was performed using SPHINXIQ software, and subgroup analyses were performed using T-tests and Chi-square tests.

RESULTS

The population was 92.7% male, with an average age of 28.5 and 3 missions in hot countries. 90% identified dehydration as a health risk, compared to 42% for hyperhydration and only 26% for drinking water without supplements. Participants reported consuming 3.2 L water/day (±1.6 L/day). Among the beverages identified as sports drinks, only 46% were suitable for rehydration during activities in hot climates. Only 25% of homemade sports drinks were appropriate. 67% of military personnel did not consume combat rations' sports drinks sachets. The reasons given were palatability for 66%, lack of variety for 22%, and consumption temperature for 11%. Experience of more than 3 missions ($p<0.05$) and knowledge of sports drinks benefits ($p<0.01$) significantly increased the consumption. 73% of military personnel monitored their hydration by urine, and concentrated urine was more of a concern (70%), than anuria (14%) or very clear urine (15%). 32% of women declared to voluntary limit their hydration, 82% to reduce urination, both proportions are significantly higher than men ($p<0.01$). Discussion: Based on the reasons for non-consumption of military sports drinks and factors related to consumption levels, some levers have been identified to increase their consumption, including experience and knowledge of their roles. Thus, pre-departure information should emphasise the benefits of sports drinks. Teaching the composition of sports drinks and their difference from energy drinks is required. Even well informed, taste is still a concern and improving their palatability is essential. Other tracks to improve behaviour are: promoting the consumption of combat rations' salty soups to avoid unpleasant temperature of warm water, insisting on specific risk of hyperhydration, and systematising use of Armstrong's urine colour scale. Avoiding self-restriction among women is critical and requires risk information, commander warning, and logistical measures.

CONCLUSION

French soldiers' knowledge and behaviour regarding hydration in hot environments can be improved, and the consumption of military sports drinks in combat rations is low.

MILITARY IMPACT

Suitable hydration is important for preserving personnel health and maintaining the operational capacity of the armed forces engaged in high-intensity combat regardless of the climate. Health education on hydration during military activities can partly change behaviour. This work has resulted in the creation of an advice sheet tailored to their needs taking into account their insufficiencies.The range of sports drinks available to French military personnel will be revised by combat rations suppliers.

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Thematic 20 : Nutrition in hot or cold environments

#46761856
Poster Presentation

Development of an individualized and strategic nutritional approach for soldiers during military expeditions in extreme cold: A multi-year field model in Greenland.

BACKGROUND

Soldiers during field training or operational missions regularly experience chronic energy deficits due to high daily energy expenditure (EE), limited appetitive responses and major logistical constraints. This deficit may impair physical and cognitive performance and compromise operational capacity. Moreover, exposure to extreme cold may worsen this negative energy balance by increasing EE and jeopardizing food logistics, preparation, and consumption.

METHODS

Several years of research have led to the development and optimization of a specific 'Extreme Cold' ration designed for tactical athletes operating in complete autonomy for approximately 15 to 20 days in Greenland (-35 to -5 °C). Food intake may be limited by volume/weight constraints, monotony, reduced palatability and foods unsuitable to a cold climate. The ration design is therefore based on five diversified core menus replayed four times throughout the expedition cycle. Rations combined freeze-dried meals and ready-to-eat sweet and salty foods, aligned with expedition eating occasions. Hot meals were prioritized at breakfast and dinner (rather than during daytime movements), and a thermos strategy was used to facilitate warm intake during daily relocations. In such extreme conditions, food is one of the only sources of comfort, palatability and individual preferences were therefore prioritized. By using diaries, we recorded food intake and calculate energy intake (EI), assess palatability and identify reasons for non-consumption contributing to body mass loss.

RESULTS

After the passage of 60 soldiers and 5 different rations tested, we came to develop an efficient solution limiting body mass loss (-1.07 ± 1.78 kg; p = 0.090). This solution was individualized and composed of a common core ration of 3666 ± 37 kcal completed by a free selection of supplemental foods (mostly ready-to-eat foods) to reach the estimated EE. Individual energy requirements were estimated from resting metabolic rate (RMR) calculated using the Harris and Benedict equation and the mean physical activity level (PAL) based on previous expeditions (PAL = 2.36 x RMR). A high-fat nutritional strategy (fat: 40-45%) increased energy density without increasing ration volume or weight, optimizing load carriage in pulkas during daily movements (ration mass of 1.03 ± 0.09 kg). Only highly palatable foods that remained easy to prepare/handle with gloves and consume (sufficiently soft) in extreme cold were included. With this formula, 87.9 ± 13.2% of the ration energy content was consumed (EI = 3966 ± 754 kcal) corresponding to 2.41 ± 2.37 kg of unconsumed foods. Micronutrient constraints were considered secondary over this short expedition; however, longer deployments would require further optimization (e.g., vitamins and sodium).

CONCLUSION

This strategic nutritional approach highlights the importance of an individualized and logistically feasible nutritional strategy to stimulate EI, limit energy deficits and body mass loss, and support physical, cognitive and nutritional status during prolonged missions in extreme cold environments.

MILITARY IMPACT

Body mass loss during multiday military training/expeditions in extreme cold may be efficiently limited by proposing palatable, cold-adapted rations that are easy to prepare and consume, and by offering partial choice to improve acceptability and match estimated energy requirements.

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Thematic 20 :
Nutrition in hot or cold environments

#46799011
Poster Presentation

Changes in iron and vitamin D status in a small sample of male rangers

BACKGROUND
Declines in iron and 25-hydroxyvitamin D [25(OH)D] status have been observed after basic military training as well as saturation diving, with insufficiencies associated to reduced physical fitness and increased risk of bone stress injury. Energy deficit during field exercises and arduous training can exacerbate inhibition of iron uptake after physical activity. Furthermore, high-tempo military training and weight-management of carried loads could increase the risk of inadequate nutrient intake. We aimed to investigate incidence of iron and vitamin D deficiencies in Swedish rangers, and changes in these markers after training.

METHODS
Blood samples were collected from male combat diver trainees and non-diving ranger soldiers (n=12, 23±3 years,183±7 cm, 87.9±6.9 kg), and analyzed for ferritin, transferrin saturation, hemoglobin (HB), C-reactive protein (CRP) and 25(OH)D before and after two 8-week diver course training periods. Collection was performed at baseline before the first diver training period (Aug-Sept), at 3 months (Oct), at 7 months before the second diver training period (Feb-March), and 9 months (June). Changes in variables were compared to baseline with paired t-test within the full group, and differences in change between divers (n=5) and non-divers (n=7) with unpaired t-test. Baseline 25(OH)D levels were compared with levels measured in Feb-March, while ferritin and HB were compared after 9 months after the full training period.

RESULTS
Mean 25(OH)D levels were significantly decreased at 7 months from 100±23 nmol/L to 65±16 nmol/L (mean difference -34 nmol/L, 95% CI -45 to -23), with no difference in change between groups (mean difference -8 nmol/L, 95% CI -31 to 15). Insufficient 25(OH)D levels (25-49 nmol/L) were observed in two non-divers (16.7%) in follow-up measurements, one at 3 months and one at 7 months. No cases of iron deficiency (ferritin <30 µg/L, or ferritin <70 µg/L if CRP ≥3 mg/L) were observed throughout the study period. After diver training at 9 months, no difference was detected in ferritin (mean difference 12 µg/L, 95% CI -12 to 35) or HB (-0.8 g/L, -5.3 to 3.7). Differences in change in ferritin and HB levels between divers and non-divers did not reach significance (43 µg/L, 95% CI -3 to 89 and -6 g/L, -15 to 3).

CONCLUSION
Vitamin D insufficiency and decrease in 25(OH)D levels were observed after winter months, in agreement with previous findings on seasonal variations, while no iron deficiency or decline in iron status was detected after arduous training in this small sample of healthy men.

MILITARY IMPACT
The observed incidence of vitamin D insufficiency reinforces the importance of supplementary strategies to prevent seasonal deficiency and associated health risks in military personnel.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

Salle Lucienne et André Blin - Mod: M. Thomas Pohl + MPR/T. Reilly

ORAL PRESENTATIONS

Between Brain and Trauma: Mild Traumatic Brain Injury, Repeated Blast Exposure, and PTSD in Contemporary Warfare

Evaluation of Exoskeleton Feasibility in F-35 Maintenance

The U.S. Army's Holistic Health and Fitness System Accelerates Recovery Time from Musculoskeletal Injuries

Physical Therapy Return-to-Run Criteria for United States Military Service Members Following Anterior Cruciate Ligament Reconstruction

Sport in the Reconstruction and Rehabilitation Pathways of Wounded Military Personnel: Preliminary Findings and Implications for Return-to-Duty

Perceived health and readiness for duty following return to duty from a musculoskeletal injury in US Army soldiers.

Adaptations in pain and physical function following high-frequency blood flow restriction training in individuals with persistent knee pain: The ADAPT multicentre randomised controlled trial

POSTER PRESENTATIONS

Simple Lateral Ankle Sprain: Assessment of Return to Sport Following an Eccentric Fibular Muscle Strengthening Protocol

Contemporary challenges in care and recovery pathways for military personnel with post-traumatic stress disorder: a qualitative study of relational dynamics (TRAUMADYN)

Criteria to Determine Readiness for Running in Military Service Members After ACL Reconstruction: A Scoping Review

Neuromuscular Variability Under Visual Uncertainty in Military Service Members Following ACL Injury: A Preliminary Study

Lack of effectiveness of a supervised return-to-sport program in preventing recurrent lower limb musculoskeletal injuries: a secondary prevention study in a French Army regiment

A remote rehabilitation solution to improve return to duty in service members with dizziness

Short-term muscle disuse lowers translational capacity but does not affect postprandial anabolic signaling

Sham was no better than active low-level laser therapy in returning military trainees to duty after metatarsal or tibial stress fractures - a randomized controlled trial

Current perspectives of late-stage rehabilitation and return to duty criteria following lower limb musculoskeletal injury in military personnel: a practitioner survey

Thematic 21 : Post-injury rehabilitation and return-to-duty

#46231888
Oral Presentation

Between Brain and Trauma: Mild Traumatic Brain Injury, Repeated Blast Exposure, and PTSD in Contemporary Warfare

BACKGROUND
Modern military operations expose personnel to repeated blasts and concussive events, causing mild traumatic brain injuries that often co-occur with post-traumatic stress disorder, creating complex clinical presentations. Historical lessons from the First World War in France show diagnostic overshadowing, while contemporary conflicts such as Ukraine demonstrate that similar challenges persist, highlighting the need to clarify the interplay between brain injury and post-traumatic stress for effective care and operational readiness. The objective of this work was to clarify the clinical and operational implications of symptom overlap between mild traumatic brain injury and post-traumatic stress disorder in military populations, using literature data and findings from a French military cohort.

METHODS
We conducted a narrative review of emerging literature on neuropsychiatric consequences of repeated mild traumatic brain injury and post-traumatic stress disorder, focusing on shared symptoms such as cognitive slowing, emotional dysregulation, sleep disturbances, irritability, and executive dysfunction, as well as underlying neurobiological mechanisms including axonal injury, neuroinflammation, and altered threat-processing networks. To complement this, we analyzed data from the DEPIS-TC study, a retrospective monocentric evaluation of systematic brain injury screening in military patients with post-traumatic stress disorder at a French military training hospital.

RESULTS
Evidence indicates substantial symptom overlap between brain injury and post-traumatic stress, complicating differential diagnosis. In the DEPIS-TC study, 39.4% had a prior brain injury and 48.5% experienced repeated subconcussive impacts. These findings illustrate the complexity of military patients presenting with overlapping neurological and psychiatric symptoms and underscore the potential value of multimodal assessment, including neuropsychological testing, longitudinal symptom monitoring, and ecological evaluation.

CONCLUSION
Refining the interplay between brain injury and post-traumatic stress is essential for directing military personnel toward appropriate and effective care. Beyond nosographic classification, a pluralistic, clinically grounded approach integrating neurological follow-up, psychiatric treatment, and rehabilitation can help navigate diagnostic complexity and avoid therapeutic impasses. Historical lessons and contemporary battlefield realities highlight the importance of tailored care strategies for soldiers exposed to repeated trauma.

MILITARY IMPACT
Accurate identification and management of overlapping brain injury and post-traumatic stress symptoms are critical to sustaining operational readiness. Implementing systematic screening and multimodal assessment and integrated care pathways could guide timely interventions, reduce functional impairment, and support long-term health and performance in high-intensity conflict environments.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46699023
Oral Presentation

Evaluation of Exoskeleton Feasibility in F-35 Maintenance

BACKGROUND
Exoskeletons are designed to support users in performing physically straining tasks. With the transition from the F-16 to the F-35, maintenance technicians of the Dutch Ministry of Defence are increasingly required to work in overhead positions or in bent and kneeling postures due to the aircraft's larger size and height. These higher physical demands contribute to increased musculoskeletal fatigue and related complaints. This study aimed to investigate the feasibility of exoskeletons for F-35 maintenance using an implementation guideline specifically developed for evaluating exoskeleton use in military contexts.

METHODS
Safety officers involved in F-35 maintenance followed the guideline independently. The guideline exists of four phases: workplace assessment, exoskeleton selection, evaluation and implementation. A tool was developed to enable safety officers assess the workplace and select use cases. Evaluation consisted of questionnaires and semi-structured interviews with maintenance technicians.

RESULTS
Safety officers were able to follow the guideline successfully. Two main use cases were identified, namely working in a kneeling and bended position on top of the F-35, for which back-support exoskeletons were selected, and working overhead in a standing position underneath the aircraft, for which arm-support exoskeletons were selected. Although technicians reported reduced fatigue and discomfort during physically demanding tasks when using exoskeletons, overall usage was limited. Task variability required frequent donning and doffing, and physically demanding tasks were not performed on a weekly basis. Additionally, technicians perceived some exoskeletons as bulky and concerns were expressed about scratching the paint of the aircraft. A notable barrier was the military mindset. Several technicians preferred relying on physical training to manage muscle fatigue and were hesitant to use external support. Some were also concerned that the support of an exoskeleton would reduce their physical strength. Technicians who reported the most positive attitudes toward exoskeletons were the ones who had a history of musculoskeletal injuries.

CONCLUSION
Applying the guideline showed that broader acceptance among technicians is fundamental for implementing exoskeletons. Clearer communication about what an exoskeleton can and cannot offer, together with stronger organizational support, is needed. As exoskeletons function as a preventive measure against injuries, emphasis should also be placed on their long-term benefits. Without aligned expectations and backing, effective and consistent use remains limited.

MILITARY IMPACT
The guideline used in this study proved to be a structured and practical approach for assessing the feasibility of exoskeletons within a military use case. Applying the guideline enables military organisations to develop and implement exoskeletons more efficiently and effectively to help reduce physical workload and prevent injuries.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46728679
Oral Presentation

The U.S. Army's Holistic Health and Fitness System Accelerates Recovery Time from Musculoskeletal Injuries

BACKGROUND
Musculoskeletal (MSK) injuries are the top medical encounter for active-duty Soldiers, the most common reason for medical discharge, and the top cause for chronic injuries in veterans. Not only are MSK injuries financially costly, but they also decrease the percentage of Soldiers who are not medically healthy enough to deploy when Soldiers are placed on limited duty. In an effort to optimize Soldier health and performance, the U.S. Army unveiled the Holistic Health and Fitness (H2F) system in 2020, which targets improving physical, nutritional, mental, spiritual, and sleep domains of Soldiers by embedding an H2F performance team, comprised of: Physical Therapists (PTs), Athletic Trainers (ATs), Occupational Therapists (OTs), Registered Dietitians (RDs), and Strength and Conditioning Coaches (S&C) into Army brigades. H2F performance teams can address a number of factors that contribute to MSK injury risk, including enhancing recovery from previous injury, improving diet, increasing sleep quantity and quality, managing environmental factors, enhancing fitness, educating Soldiers about medication usage, limiting occupational hazards, among others.

METHODS
This study analyzed data extracted from the Soldier, Performance, Health, and Readiness Database (SPHERE) at the U.S. Army Research Institute of Environmental Medicine (USARIEM) from October 2017 to September 2025 and applied regression and survival analyses with inverse probability weighting on N = 43,870,526 Soldier records to analyze the impact of the H2F system on recovery time from MSK injuries in active-duty Soldiers.

RESULTS
Soldiers exposed to H2F were 0.9 ± 0.00-percentage points ($p < 0.001$) more likely to be placed on limited duty from an MSK injury but spent 7.1 ± 0.01% ($p < 0.001$) fewer days on limited duty from MSK injuries compared to Soldiers not exposed. When evaluating only preventable MSK injuries (e.g., running, training, sports, and duty related tasks), Soldiers exposed to H2F spent 6.6 ± 0.01% ($p < 0.001$) fewer days on limited duty. The effect was larger for lower body injuries (8.5 ± 0.01%, $p < 0.001$) compared to upper body injuries (4.1 ± 0.01%, $p < 0.001$).

CONCLUSION
There is strong statistical evidence that H2F reduced the duration Soldiers spent on limited duty due to MSK injuries. This is likely due to easier access to care and early intervention provided by the H2F performance team. Direct access to care allows for better MSK injury management by administering proper rest, providing dietary counseling for recovery, improving impairments and accelerating tissue healing, and maintaining fitness. Overall, the evidence shows that investment in a large-scale early intervention system, like H2F, can reduce recovery time from MSK injuries, complementing similar findings in clinical settings. The opinions or assertions contained herein are those of the authors and do not reflect the official policy of the Department of Army, Department of War, or the U.S. Government.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46735707
Oral Presentation

Physical Therapy Return-to-Run Criteria for United States Military Service Members Following Anterior Cruciate Ligament Reconstruction

BACKGROUND

Anterior cruciate ligament (ACL) injuries are common among United States military service members and negatively impact readiness. Historically, return to full duty rates post-anterior cruciate ligament reconstruction (ACLR) have been low for service members, with only 47.4% of patients returning to full duty and 27.4% required a permanent activity-limiting profile. A lack of consensus on the optimal return-to-run (RTR) criteria presents a challenge for rehabilitation professionals guiding service members back to combat training activities which include running and jumping. Consequently, the Defense Health Agency (DHA) published the Tri-Service Post-Operative Rehabilitation Guidelines in 2020. The purpose of this survey study was to identify common RTR criteria used by physical therapists treating service members post-ACLR to provide future evidence-based updates to military-centric post-operative guidelines.

METHODS

A survey based on a similar study by Sayer et al was distributed at a military continuing education course and emailed to all active duty and civilian physical therapists within the US Army, Navy, and Air Force. Responses were allocated into categories and descriptive statistics of respondents were calculated, including level of PT degree, years of experience, board certification, and number of ACLs treated.

RESULTS

A total of 137 responses were collected and 105 were included in the study with representation from the Army (n=58), Navy (n=26), Air Force (n=8), and civilian providers (n=13). Therapists reported that the most useful areas of the DHA guidelines were the strength and functional testing recommendations (n=73, 68%), the time-based milestones (n=59, 55%), and the neuromuscular training recommendations (n=30, 28%). The most common clinical examination RTR criteria were knee extension strength (n=93, 87%) single leg squat (n=83, 78%), pain via NRS/VAS (n=72, 67%), time (n=72, 67%), hop test battery (n=66, 62%), clearing by a surgeon (n=56, 52%), and knee flexion strength (n=44, 41%). Limb Symmetry Index (LSI) percentage was the most prevalent cut-off variant with 41 responses ranging from 70% to 90%. Therapists' response on the minimum number of weeks to RTR ranged from 8 to 24 weeks with a mean of 13.16 ± 3.01 weeks. The most common responses were 12 (n=59) and 16 (n=21) weeks.

CONCLUSION

This cross-sectional study served as the groundwork for future research by surveying and analyzing physical therapists' responses regarding RTR criteria currently utilized in military populations. Due to the wide variability in criteria, with some overlapping with DHA guidelines and others deviating, additional high-quality studies with large sample populations are needed to further optimize return to duty for service members following ACLR.

MILITARY IMPACT

Improved understanding of effective guidelines for rehabilitation professionals enhances readiness and combat power, especially important during large scale combat operations where optimizing return-to-duty is paramount.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46789855
Oral Presentation

Sport in the Reconstruction and Rehabilitation Pathways of Wounded Military Personnel: Preliminary Findings and Implications for Return-to-Duty

BACKGROUND
The multiplication of MASCAL exercises reflects increasing consideration of the consequences of high-intensity combat. In this context, injury constitutes a major source of operational disruption within armed forces. While technology plays a central role in rearmament strategies, the resilience of the soldier and their ability to return to duty remain critical factors. High-intensity combat exposes soldiers to injuries that may result in physical impairments and post-traumatic stress disorder (PTSD), requiring not only biomedical but also social approaches to rehabilitation. Rehabilitation cannot therefore be considered complete without taking into account the soldier's socio-professional environment. Predominantly biomedical and functional approaches remain insufficient insofar as they overlook key identity dimensions affected by injury. For over a decade, the French Armed Forces have mobilized sport as a rehabilitation tool. Although this use of sport is often presented as self-evident in relation to military identity, its differentiated uses and effects within reconstruction pathways remain insufficiently documented.

METHODS
This study is primarily based on 25 semi-structured interviews lasting between two and five hours, conducted outside the institutional framework. Data collection, carried out as part of an ongoing doctoral research project, is now complete. The material is currently undergoing a typological analysis of reconstruction pathways, with a particular focus on identity reconstruction processes.

RESULTS
Institutional uses of sport appear to rely on the assumption that sport is intrinsically linked to military identity. Our findings suggest, however, that soldiers' appropriation of sport is shaped by a socially structured trajectory within the institution. Soldiers integrate sport into their identity reconstruction in heterogeneous ways. Typologies of pathways emerge according to the nature of the injury and the role previously played by physical activity prior to its occurrence. In some cases, sport becomes central and an end in itself. In others, it functions as a vehicle for the transmission of experience. Finally, sport may serve as a means of disengagement, with some soldiers ultimately reconstructing themselves outside the institution. Conclusion Adopting a holistic perspective on the impact of injury allows for a more accurate understanding of soldiers' lived experiences. This sociological study shows that sport cannot fully address the diversity of injuries, contexts of occurrence, and professional and social experiences shaping reconstruction pathways.

MILITARY IMPACT
A holistic approach to injury management is essential in the current context to optimize return-to-duty processes. Adapting sport-based rehabilitation strategies to individual profiles, while avoiding uniform prescriptions of practice, appears crucial. Furthermore, strengthening the articulation between sport and socio-professional support may enhance injured soldiers' adherence to rehabilitation programs and contribute to more sustainable return-to-duty outcomes.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46811631
Oral Presentation

Perceived health and readiness for duty following return to duty from a musculoskeletal injury in US Army soldiers.

BACKGROUND
Musculoskeletal injuries (MSKI) are a large detriment to military readiness, with as many as half of a military unit sustaining an MSKI every year. Subsequently, nearly half of those injured who return to duty (RTD) will sustain a subsequent injury in the following year. Understanding soldiers' baseline health status upon return to duty can help identify any health deficits that require attention. The purpose of this study was to characterize the perceived health and readiness of Soldiers after they were cleared to return to duty from an MSKI and compare these perceptions between spine and lower extremity disorders.

METHODS
This was a prospective cohort study. US Army soldiers cleared to return to duty without limitations following a lumbar/thoracic spine or lower extremity injury from three large military hospitals were recruited. Eligibility required no longer being on a limited duty profile and no plans to seek further care. Soldiers with concurrent injuries in other locations or planning to separate from the military within the next 10 months were also excluded. Eligible participants completed questionnaires about their perceived health and readiness.

RESULTS
There were 469 participants, mean age (SD) of 27.1 (6.1) years, 14.1% female, 87.9% enlisted, and 36.5% in a combat unit. Soldiers had a mean (SD) of 9.8 physical therapy visits prior to being returned to duty. Once cleared for duty, 16.2% disagreed with the statement that they did not need any further medical care before returning to duty, and 11.3% believed they would not be able to pass the Army Physical Fitness Test. 14.7% did not feel they could wear their full-body armor or carry/use their assigned weapon if they had to deploy right then. Only 72.9% of all soldiers felt 100% mission-capable based on their occupational specialty and wartime requirements, and 66.3% had some pain during movement assessments after being cleared for full duty. Mean kinesiophobia, fear avoidance beliefs, and pain catastrophizing were all low, indicating no risk of psychological distress upon returning to duty. Only 20.7% perceived their health as excellent, and 48.0% as very good. Sleep quality was poor for 1 in 4 Soldiers. Most of these metrics were similar between soldiers with lower-extremity injuries and those with spine injuries.

CONCLUSION
Many Soldiers returning to duty from an MSKI do not perceive their health as optimal, with one in four Soldiers reporting they are not 100% mission capable. Approximately one in ten did not believe they could reach the minimum required passing score on their fitness test. Optimizing performance and health should be considerations for returning all soldiers to full duty following an MSKI.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#47038567
Oral Presentation

Adaptations in pain and physical function following high-frequency blood flow restriction training in individuals with persistent knee pain: The ADAPT multicentre randomised controlled trial

BACKGROUND
Persistent knee pain is associated with impaired physical function, pain, and muscle weakness. Heavy-load resistance training (HL-RT) is a key component of rehabilitation to address these impairments; however, its use may be limited by pain and load intolerance. Low-load blood flow restriction (LL-BFR) offers an alternative approach. This study compared the effects of high-frequency LL-BFR with HL-RT on physical function, muscular strength, and pain in individuals with persistent knee pain.

METHODS
A multicentre, randomised controlled trial was conducted across five sites, recruiting 60 military personnel with persistent knee pain (LL-BFR: n = 31; HL-RT: n = 29) who attended a three-week residential rehabilitation course. Participants were randomised to either: a) LL-BFR, twice daily at 20% 1-repetition maximum (RM) or b) HL-RT three-times per week at 70% 1-RM. The primary outcome was the Lower Extremity Functional Scale (LEFS) assessed at admission (T1), discharge (T2), and 12-weeks post-intervention (T3). Secondary outcomes included patient-reported measures of pain, function and fear of movement, as well as clinical assessments of strength and movement quality. Linear mixed-effects modelling evaluated intervention effects across timepoints.

RESULTS
LEFS scores increased significantly in the LL-BFR group at T2 (Δ 5.7±10.5, d = 0.54, p = 0.001) and T3 (Δ 8.4±8.6, d = 0.98, p< 0.001), with no significant changes observed in the HL-RT group. At T3, a significant between-group difference favoured LL-BFR (adjusted difference in Δ 6.8, 95%CI 1.8-11.7, p= 0.008). Improvements in KOOS Pain, KOOS ADL subscales and MSKHQ scores were consistent with these findings. Both interventions resulted in significant improvements in functional strength. Unilateral leg press increased with large effects at T2 (LL-BFR: Δ 21.2 ± 13.2, HL-RT: Δ 18.8 ± 17.8, both p <0.001) and a medium-to-large effect at T3 (LL-BFR: Δ 20.0 ± 11.5, HL-RT: Δ 18.2 ± 28.0, both p <0.001), with no between-group differences. Similar patterns were observed for hip and knee isometric strength, calf endurance, and movement quality, with no significant between-group differences.

CONCLUSION
LL-BFR represents an effective and time-efficient RT alternative for individuals unable to tolerate heavy loads, particularly in rehabilitation settings where rapid functional recovery is essential.

MILITARY IMPACT
Persistent knee pain significantly limits deployability, load carriage capacity, and physical readiness in military personnel. The ability of high-frequency LL-BFR to improve pain and function within a short residential rehabilitation timeframe offers a practical strategy to accelerate recovery while minimising joint stress. Incorporating LL-BFR into military rehabilitation pathways may enhance return to duty timelines, maintain operational capability, and reduce medical downgrading in personnel unable to tolerate conventional heavy-load training.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#1000056
Poster Presentation

Simple Lateral Ankle Sprain: Assessment of Return to Sport Following an Eccentric Fibular Muscle Strengthening Protocol

BACKGROUND
Lateral ankle sprain (LAS) is the most common sports-related osteoarticular injury and a frequent concern in general medicine. Still too often underestimated, LAS is characterized by a high recurrence rate and a significant risk of progression to chronic ankle instability, even after a first episode. Its impact on sports participation is substantial, notably in terms of training absenteeism and reduced athletic performance. Return to sport (RTS) is most often inadequate and, in the majority of cases, premature. The aim of this study was to demonstrate that eccentric strengthening of the ankle evertor muscles enables a higher-quality RTS, in terms of functional parameters, compared with concentric strengthening. The secondary objective were to confirm the initial findings obtained in a previous study using our protocol, supporting the superiority of this strengthening modality with regard to muscle strength recovery and proprioceptive recovery following LAS.

METHODS
Our study was a simple-blind randomised controlled tria, conducted at the Laveran Military Hospital in Marseille. Included patients were randomized into 2 groups : one group underwent rehabilitation according to an eccentric muscle-strengthening protocol, while the other underwent concentric rehabilitation. The initial assessment consisted of an isokinetic test and 2 posturographic examinations. RTS was evaluated using a questionnaire developed for the purposes of the study, and administered one year after the injury.

RESULTS
A total of 52 patients were included between 2015 and 2017 (63.5% military personnel ; mean age: 30.7 years). The results of the isokinetic assessment demonstrated complete recovery in 76.9% of patients in the eccentric group, compared with 26.9% in the concentric group ($p < 0.001$). Furthermore, proprioceptive improvement was observed in 42.8% of patients in the eccentric group, versus 16.2% in the concentric group ($p = 0.10$). At one year, RTS occurred more rapidly and more frequently at a higher level in the eccentric group than in the concentric group, although the difference did not reach statistical significance.

CONCLUSION
Eccentric strengthening of the fibular muscles following LAS results in superior muscle strength and proprioceptive recovery. It also appears to improve the quality of RTS by enabling a faster return at a level comparable to, or even higher than, the pre-injury level. Finally, performing isokinetic and posturographic assessments at the end of rehabilitation appears to be fairly predictive of successful RTS and could assist clinicians in guiding the management of athletes, particularly in cases of severe LAS.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#1000058
Poster Presentation

Contemporary challenges in care and recovery pathways for military personnel with post-traumatic stress disorder: a qualitative study of relational dynamics (TRAUMADYN)

BACKGROUND
Post-traumatic stress disorder (PTSD) among military personnel has increasingly become not only a clinical issue, but also a social, institutional, and administrative concern. Recent conflicts have contributed to greater recognition of psychological injuries within military populations, as well as to the development of structured care and rehabilitation pathways involving multiple actors. Current research in military mental health has largely focused on access to care, coordination of services, rehabilitation programs, and psychotherapeutic approaches. Despite these advances, many military personnel with PTSD experience discontinuities in care pathways and difficulties maintaining long-term engagement in care and rehabilitation processes. These findings suggest that recovery trajectories depend not only on clinical approaches, but also on relational and institutional dynamics.
This project aims to explore the relational dynamics involved in care and recovery pathways among military personnel with PTSD. Particular attention is given to the reciprocal relationship between trauma and interpersonal dynamics: the effects of PTSD on interpersonal, therapeutic, and institutional relationships, and conversely, the impact of these relationships on recovery trajectories, continuity and disruptions within care pathways. The study also examines the role of therapeutic alliance, institutional frameworks, supportive third parties, and interdisciplinary coordination in shaping recovery processes.

METHODS
This study is based on a qualitative methodology using semi-structured interviews. The study will include three populations: military personnel with PTSD, healthcare professionals, and non-healthcare actors involved in care and rehabilitation pathways. Eight to ten military personnel with PTSD will be recruited, each identifying three to five actors involved in their care and rehabilitation pathways, resulting in approximately 32 to 48 interviews.
Data analysis will be conducted using NVivo software and supported by a multidisciplinary committee of psychiatrists and psychologists specialized in military psychiatry and PTSD.

CONCEPTUAL FRAMEWORK
This work proposes to conceptualize care and recovery pathways as interfaces in which multiple actors, institutional logics, representations, affects, and expectations interact. Within these spaces, care-seeking processes and recovery trajectories are continuously negotiated, transformed, supported, or hindered through interpersonal and institutional relationships.

CONCLUSION
This research aims to contribute to contemporary reflections on military mental health care and rehabilitation by highlighting the central role of relational dynamics in recovery processes and continuity of care. Beyond the coordination of services alone, the findings may help better understand how care pathways can remain coherent, supportive, and meaningful for military personnel experiencing PTSD.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46603690
Poster Presentation

Criteria to Determine Readiness for Running in Military Service Members After ACL Reconstruction: A Scoping Review

BACKGROUND
Anterior cruciate ligament (ACL) injuries are a critical concern for military populations. Service members (SM) are often required to perform high-impact activities, putting them at increased risk of ACL injury. Of those injured, only 47% return to full duty without physical limitations, and the rates of posttraumatic osteoarthritis and psychosocial impact are greater than those of civilians. Return to running (RTR) is a critical milestone during ACLR rehabilitation as it is an essential component of military performance and career longevity. Despite this importance, there are no standardized clinical criteria for determining readiness for RTR in this unique population. Purpose/Aims: To (1) synthesize the literature addressing postoperative ACLR RTR criteria in an active-duty military population and (2) inform decision-making for clinicians determining SM's readiness for RTR.

METHODS
We conducted a comprehensive review of PubMed, Embase, and SPORTDiscus. Our criteria were articles with an active-duty military population following ACLR and discussion of criteria for determining readiness to RTR. The search for gray literature was limited to postoperative protocols specific to military treatment facilities. Two researchers reviewed all abstracts to identify those that met inclusion and exclusion criteria. A full-text review of potentially eligible studies was then conducted. Disagreements on study inclusion were decided by a third senior researcher.

RESULTS
One narrative review and two grey literature resources met our criteria. The narrative review discussed general return to activity parameters based on time from surgery and patients' functional needs, but no objective criteria were proposed to determine readiness to RTR. The grey literature included two postoperative rehabilitation protocols that use objective criteria for RTR. The Defense Agency Tri-Service postoperative protocol uses pain-free hopping and the ability to perform ≥ 90% of uninvolved limb maximal single-leg squats. The protocol from the United States Military Academy at West Point is similar; however, it requires ≥75% quadriceps strength limb symmetry.

CONCLUSION
Limited literature resources were found describing clinical decision-making for RTR in the military population. Currently there is no consensus on objective criteria to determine readiness for RTR in the military. Further research is needed to determine criteria to inform clinician decision-making for military SM's readiness for RTR after ACLR.

MILITARY IMPACT
Military SMs face unique challenges recovering from ACLR and are at high risk of failing to return to duty. Running is a key component of military performance, yet it is often overlooked in the recovery process. Currently, there is no consensus in the literature regarding RTR in this population and further research must determine optimal criteria to safely and successfully guide SMs to this crucial rehabilitation landmark.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46728932
Poster Presentation

Neuromuscular Variability Under Visual Uncertainty in Military Service Members Following ACL Injury: A Preliminary Study

BACKGROUND

Anterior cruciate ligament (ACL) injuries are prevalent among military service members (SMs) and can critically undermine military readiness. A ruptured ACL could disrupt vital sensory feedback from the knee to the brain, creating neuromuscular instability that can persist even after surgery. This may force SMs to rely on slower visual cues for movement, which could be detrimental when returning to duty. This research aims to quantify this instability using muscle activation variability as a metric.

METHODS

Nine participants (3–4 months post-ACL reconstruction) completed a visually guided stepping task in virtual reality across five blocks (70 trials per block). Knee motion trackers controlled a virtual sphere that participants guided to a target. Visual feedback was manipulated to introduce graded uncertainty in knee position (constant feedback, small disturbance, large disturbance, no feedback). Surface electromyography (EMG) was recorded from vastus medialis (VM), vastus lateralis (VL), and rectus femoris (RF) at 2000 Hz. The coefficient of variation of the EMG envelope (CoV_Env) was calculated as standard deviation divided by mean amplitude. Linear mixed-effects models were fitted separately for each muscle, with noise level and block as fixed effects and subject as a random intercept.

RESULTS

Across all muscles, increasing visual uncertainty did not significantly affect CoV_Env (all $p > 0.16$), and no significant noise × block interactions were observed (all $p > 0.11$). A descriptive increase in CoV was observed in the large disturbance condition; however, this effect did not reach statistical significance. A significant main effect of assessment block emerged in VM and VL, with Block 5 demonstrating increased EMG variability relative to Block 1 (VM: $\beta = 0.051$, $p < 0.001$; VL: $\beta = 0.087$, $p < 0.001$). Marginal R^2 values were low (VM = 0.022; VL = 0.018; RF = 0.015), indicating minimal variance explained by visual condition and block alone. In contrast, conditional R^2 values were moderate (VM = 0.319; VL = 0.356; RF = 0.648), reflecting substantial between-subject variability.

CONCLUSION

In ACL reconstruction participants, visual uncertainty did not significantly increase quadriceps EMG variability. Instead, neuromuscular variability changed over time, suggesting block-related adaptation, strategy adjustment, or fatigue. The large variance between subjects indicates that individual neuromuscular control strategies may play a greater role than external visual manipulation in shaping movement stability at this stage of recovery.

MILITARY IMPACT

These preliminary findings suggest that in the early months after ACL reconstruction, SMs may maintain stable quadriceps activation patterns under degraded visual conditions during stepping tasks. Longitudinal adaptation effects over the course of rehabilitation should be studied to determine if SMs are prepared to return to high-intensity operational environments. These preliminary findings will be further evaluated as additional participants are enrolled in our ongoing study.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46739022
Poster Presentation

Lack of effectiveness of a supervised return-to-sport program in preventing recurrent lower limb musculoskeletal injuries: a secondary prevention study in a French Army regiment

BACKGROUND
Sports-related musculoskeletal injuries of the lower limbs represent a public health issue due to their frequency and the resulting absenteeism from work. In military personnel, they lead to a decrease in the operational potential of combat units. A recent history of injury is an identified risk factor for new injuries, with the risk of prolonging the period before unrestricted return-to-duty. Consequently, both the rehabilitation and return-to-sport phases are important to consider maximizing soldiers' operational readiness

METHODS
Non-randomized interventional study including patients from a French Army regiment suffering from lower limb musculoskeletal injuries not requiring surgical intervention and resulting in a sports absence of more than 10 days. After the initial treatment phase, followed by the rehabilitation phase carried out according to physicians' recommendations, the patients were divided into two groups based on their squadron. Patients in the "Supervised return-to-sport" group received oral and written information and dedicated supervised sport sessions; those in the "Control" group managed their return-to-sport independently. The end of the return-to-sport phase marked the return-to-duty without restrictions, with a physician's approval. The primary outcome was the occurrence of a new lower limb injury within 3 months of unrestricted return-to-duty. Sporting abilities were assessed using standardized French military sports tests (CCPM), quality of life was assessed using the Nottingham Health Profile, and the duration of the return-to-sport phase was calculated. Intergroup comparisons were assessed using t-test and chi-square test.

RESULTS
Over 20 months, 63 patients (mean age 26.1±5.0 years, 8 women) were included. Related to the regiment's size, this represented an incidence of 6.8 non-surgical lower limb injuries per 1,000 people/month (95% CI = [6.66; 6.94]). 61.9% of injuries were sustained on duty; ankle sprain was the most frequent injury (44.4%). 8 patients were lost to follow-up after initial management, bringing the total number of patients considered for statistical analysis to 55. No difference was observed in the duration of return-to-sport phase. 8/32 patients in the " Supervised return-to-sport " group (25.0%) and 6/23 patients in the "Control" group (26.1%) sustained a new injury within three months of returning to unrestricted activities (p = 0.92). No significant differences were observed in athletic ability or quality of life after return-to-duty.

CONCLUSION AND MILITARY IMPACT
A simple protocol guiding the return-to-sport for military personnel with lower limb injuries showed no benefit compared to an unsupervised return-to-sport. However, limitations were noted, particularly regarding the limited number of sports slots available to these military personnel. Increasing the number of weekly sessions could provide a real benefit in secondary prevention and should be evaluated in future studies.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46765095
Poster Presentation

A remote rehabilitation solution to improve return to duty in service members with dizziness

BACKGROUND

Vestibular conditions cause dizziness and balance issues which can limit the ability to complete activities of daily living. Vestibular dysfunction is common in the civilian population, especially in older adults. It is also common in service members, often related to mild traumatic brain injury, which reduces readiness. One of the biggest barriers to successful vestibular rehabilitation is poor compliance to the prescribed at-home rehabilitation program, which can delay return to duty. Exercise gamification has been shown to improve rehabilitation compliance. The research team has previously utilized a user-driven design approach to develop VestRx™, a novel at-home vestibular rehabilitation system targeted for older adults. The system consists of a mobile app that uses the front-facing camera to track motion and control the rehabilitation games and provide feedback. There is also a clinician portal that can be used to remotely monitor patient performance and adjust exercise prescription. As the patients and care environment for service members are notably different from the civilian system, the research team worked with military partners to adapt the application to meet the needs and preferences of military patients and clinicians. The goal of the study was to evaluate the usability and obtain feedback from military clinicians on a prototype of the VestRx-MIL application.

METHODS

In accordance with the Navy Medical Center San Diego IRB, nine military clinicians with experience treating vestibular conditions participated in a demonstration of the prototype app. They were shown how the app and portal work and then provided an opportunity to try it themselves. Following the demonstration, participants completed the System Usability Scale (SUS) and responded to an open-ended questionnaire.

RESULTS

The participants rated VestRx-MIL an average of 71±15 (out of 100) on the SUS. Overall, clinicians liked the app and tracking abilities of the clinician portal. Main feedback was focused on improving the user interface and workflow to be more modern and adding more exercises and customizability. There was some general concern about additional time and financial support for using the app, both of which are in short supply at clinics.

CONCLUSION

Overall, the perception of VestRx-MIL was positive. A score greater than 68 is considered above average on the SUS; an average of 71 within our study indicates that the prototype app is promising, but can still be improved. This feedback is being used to refine the application. A final version will be evaluated in-clinic and at-home by patients. The results will be used to establish the feasibility of implementing VestRx-MIL in vestibular rehabilitation.

MILITARY IMPACT

By tailoring the system to the military population, VestRx-MIL has the potential to improve clinical care and thus accelerate return to duty and readiness. Vest-Rx™ provides expanded treatment through at-home practice and remote monitoring. Additionally, VestRx-MIL will improve access to care by enabling expert vestibular care in remote locations where no vestibular specialists are available. A vestibular specialist can use VestRx™ to remotely monitor patients and prescribe their rehabilitation exercises. This could include active service members that encounter vestibular problems while being deployed, as well as veterans in rural locations who suffer from more chronic vestibular problems.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46802368
Poster Presentation

Short-term muscle disuse lowers translational capacity but does not affect postprandial anabolic signaling

BACKGROUND
Post-injury muscle disuse induces rapid muscle loss that is attributed in part to decreased postprandial muscle protein synthesis. While this response is well documented, defining underlying mechanisms remains critical for developing targeted interventions. This study aimed to determine the effect of short-term disuse on basal translational capacity and the acute anabolic signaling and 26S proteasome response to protein ingestion.

METHODS:
Twelve healthy participants (3F/9M, 20 ± 2 y, 26 ± 3 kg/m2) underwent 5 days of leg immobilization with a rigid knee brace (Donjoy X-ACT; 60° flexion) and crutches. Vastus lateralis muscle biopsies were collected from the immobilized (DISUSE) and non-immobilized (ACTIVE) legs at baseline (0 min; 8-hr overnight fast) and 90 minutes after consuming 25 g of whey protein once the brace was removed. Total RNA concentration (µg RNA/mg muscle) was assessed in baseline samples as a proxy for translational capacity since cellular RNA is >85% ribosomal RNA. Anabolic signaling (Western blot) and proteolytic activity of the 26S proteasome (chymotrypsin-, trypsin-, and PGPH-like catalytic sites) were assessed at 0 and 90 minutes. Protein phosphorylation was expressed as fold change relative to ACTIVE baseline. Proteolytic activity was normalized to samples with proteasome inhibitors and expressed as relative fluorescence units (RFU).

RESULTS
Baseline muscle RNA concentration was lower (P<.001) in DISUSE (0.42 ± 0.06 ug/mg) compared with ACTIVE (0.51 ± 0.09 ug/mg). There was an increase (P<.001) from 0 to 90 min in p-mTORSer2448 (1.0 ± 0.3 vs. 3.0 ± 1.2), p-p70Thr389 (1.0 ± 0.8 vs. 167 ± 114), p-rpS6Ser240/244 (1.6 ± 3.5 vs. 111 ± 71), with no difference (P<.05) between legs. PGPH-like and chymotrypsin-like proteolytic activity increased (P<.05) from 0 to 90 min in ACTIVE (PGPH: 125 ± 29 vs. 161 ± 43; Chymotrypsin: 1155 ± 315 vs. 1384 ± 407 RFU) but remained unchanged (P>.05) in DISUSE (PGPH: 141 ± 35 vs. 144 ± 24; Chymotrypsin: 1308 ± 319 vs. 1277 ± 276 RFU). Trypsin-like activity did not change (P>.05) from 0 to 90 min in ACTIVE (18.7 ± 5.2 vs. 18.2 ± 6.3 RFU) but decreased (P<.05) in DISUSE (20.0 ± 5.7 vs. 13.0 ± 7.0 RFU) such that enzymatic activity at 90 min was less than (P<.05) ACTIVE. There were no differences (P>.05) between ACTIVE and DISUSE at 0 min.

CONCLUSION
Muscle disuse suppressed the proteolytic response to protein ingestion, suggesting short-term disuse reduces muscle protein turnover. This altered response to protein feeding appears driven by declines in translational capacity but not postprandial anabolic signaling.

MILITARY IMPACT
Skeletal muscle adapts to decreased loading after only five days. These findings suggest targeted interventions should be implemented early after injury and prioritize the preservation of protein turnover machinery rather than anabolic signaling. Application of such intervention may better preserve muscle mass and accelerate return-to-duty following injury.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#46812906
Poster Presentation

Sham was no better than active low-level laser therapy in returning military trainees to duty after metatarsal or tibial stress fractures - a randomized controlled trial

BACKGROUND
Lower extremity stress fractures are one of the most consequential injuries in military service members, disproportionately affecting trainees. They represent a substantial source of morbidity, training disruption, and health care utilization, with incidents as high as 40% reported in trainees. The purpose of this study was to compare the effectiveness of active versus sham low-level laser therapy (LLLT) on graduation rates in military trainees with lower extremity stress fractures. The secondary aims were to compare pain and physical function outcomes.

METHODS
Participants were trainees at the Medical Education and Training Campus, San Antonio, Texas, with an MRI-confirmed metatarsal and/or tibial stress fracture, enrolled between June 2023 and November 2024. All participants received standard-of-care treatment and were randomized to either active or sham LLLT. The primary outcome was on-time graduation at four months, and secondary outcomes included the Defense and Veterans Pain Rating Scale (DVPRS) and Lower Extremity Functional Scale (LEFS), also at four months. Changes in bone healing were assessed on magnetic resonance imaging from baseline to four months.

RESULTS
The mean age (SD) was 23.7 (4.7) years, 54.4% female, and 80.6% in the US Army. In 46.6% of the cohort, both extremities were affected; tibia involvement was 69.9% and metatarsal 30.1%, with severity of stress fractures ranging from grade I to IV. Only 36.9% of participants graduated without delays. There was no statistically significant difference in graduation rates between sham or active treatment groups. Furthermore, sex, laterality, and stress fracture location did not predict successful graduation rates. Pain (mean difference[95CI] DVPRS -0.7312 [-2.308,0.8456]) and function (mean difference[95CI] LEFS 5.8101 [-8.0288,19.649]) were also not significantly different.

CONCLUSION
Graduation rates, pain intensity, and physical function did not differ significantly between military trainees who received LLLT and those who received sham. Given the substantial resource investment, the routine use of LLLT may impose unnecessary burdens on both trainees and healthcare systems and is not recommended.

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Thematic 21 : Post-injury rehabilitation and return-to-duty

#47038349
Poster Presentation

Current perspectives of late-stage rehabilitation and return to duty criteria following lower limb musculoskeletal injury in military personnel: a practitioner survey

BACKGROUND
Lower limb musculoskeletal injuries (MSKIs) are a leading cause of reduced operational capability and medical discharge in UK military personnel. Late-Stage Rehabilitation (LSR) is critical for restoring function and readiness for return to duty (RTD) yet remains underrepresented in research and clinical guidelines. This service evaluation examines current practices, perspectives, and challenges among UK Defence rehabilitation practitioners and physical training instructors (PTIs) in delivering LSR and facilitating RTD for lower limb MSKIs.

METHODS
A cross-sectional survey was distributed to UK Defence rehabilitation practitioners and Army PTIs. The survey collected demographic, quantitative, and qualitative data on LSR exercises, outcome measures, RTD criteria, and perceived challenges. Quantitative data were analysed descriptively; qualitative responses were examined using inductive content analysis.

RESULTS
157 responses were received across all services and levels of care, with respondents averaging 8 years of clinical experience. LSR commonly included resistance training, plyometrics, running, and load carriage. PTIs most frequently reported low cardiovascular fitness as a deficit persisting after rehabilitation. A range of outcome measures were used to guide progression and RTD; though, there was inconsistency regarding their relevance and application across all branches of the UK Military. Only 48% of rehabilitation practitioners reported using a formal RTD criteria, while 78% used structured handover tools. Common challenges included time constraints, limited access to resources and low patient compliance and confidence.

CONCLUSION
LSR and RTD practices for lower limb MSKIs are variable across military rehabilitation settings. There is a clear need to balance standardisation with individualised care based on patient needs and occupational roles. Clear role delineation and communication between rehabilitation practitioners and PTIs are essential during the transition phase. Addressing persistent challenges such as limited time, resources, deconditioning, rehabilitation compliance, psychological readiness may improve LSR effectiveness.

MILITARY IMPACT
Optimising Late-Stage Rehabilitation directly supports force readiness, deployability, and operational effectiveness within the UK Armed Forces. Inconsistent RTD criteria and variable LSR practices may increase the risk of re-injury and delay deployability,, with associated impacts on workforce sustainability and operational capability. Standardising key components of LSR while maintaining occupational specificity can enhance physical resilience, and improve safe, timely RTD in high-demand military environments.

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Thematic 22 : Biomechanics of load carriage and movement

Salle Moebius - P. Newman + P. Portero

ORAL PRESENTATIONS

A Multi-Scale, Multi-Fidelity Human Digital Twin Platform for Personalized Acute and Chronic Musculoskeletal Injury Risk Assessment

Holistic Development and Evaluation of a Vertical Load Offset System for an Integrated Head Protection System

How Do We Move? Understanding Movement Strategies Across Military Tasks

A combined statistical shape modelling and iterative user-feedback design approach to developing curved hard ballistic plates for Australian Army personnel

Current Cervical Conditioning Prescriptions Do Not Match Operational Demands in Rotary-Wing Aircrew

Musculoskeletal Modeling Reveals Individual Variation in Biomechanics of Heavy Load Carriage

POSTER PRESENTATIONS

Effect of walking with an active ankle exoskeleton on lumbar biomechanical responses

Physiological and Subjective Responses to Heavy Load Carriage Systems: Informing Design Direction in a High-Load Operational Unit

Influence of Equipment Configuration and Perceived Fit on Soldier Fatigue During Rucksack Marching

Specific strength training modulates lower limb landing biomechanics in military personnel

Novel Approaches to Soldier Susceptibility Assessments: A Preliminary Analysis

Evaluating Military Equipment Configuration During Rucksack Marching

Development of a Tool to Evaluate the Effect of Headborne Equipment and Fatigue on Warfighter Burden

Impact of pitch motion on manual pulling performance and postural stability : Implications for naval operability

A musculoskeletal modelling approach to estimate soldier biomechanical load during load carriage (a preliminary study)

The effect of load carriage on task relevant and task equivalent gait fluctuations in male and female soldiers

Musculoskeletal modeling of the soldier: application to the biomechanical study of load carriage for five movements typically encountered during a mission

Thematic 22 : Biomechanics of load carriage and movement

#46604398
Oral Presentation

A Multi-Scale, Multi-Fidelity Human Digital Twin Platform for Personalized Acute and Chronic Musculoskeletal Injury Risk Assessment

BACKGROUND
Both acute overuse injuries such as bone stress fractures and chronic conditions including intervertebral disc degeneration represent leading causes of attrition and disability in military populations. Existing injury risk assessment approaches generally lack personalization, limiting analyses to population-average models, generalized loading conditions, and inability to span relevant biological timescales. We present a multi-scale, multi-fidelity human digital twin platform that enables personalized biomechanical assessment across anatomical sites, tissue types, and injury timescales.

METHODS
The platform implements a three-stage computational pipeline using anatomically correspondent models that enable information flow across fidelity and length-scale levels. Stage 1: Markerless motion capture extracts individualized kinematics and generates a personalized musculoskeletal model from video. Stage 2: Musculoskeletal modeling computes joint reaction forces, moments, and muscle forces consistent with the captured motion. Stage 3: Finite element models incorporating advanced constitutive behaviors including viscoelasticity, fatigue damage, and biphasic material response predict tissue-level mechanical states at anatomical sites of interest. The multi-fidelity architecture enables scaling from rapid reduced-order screening to high-fidelity individualized assessment. Platform capabilities were validated using two applications: tibial strain prediction during dynamic loading and intervertebral disc fatigue accumulation during prolonged seated vibration exposure.

RESULTS
Personalized tibial strain predictions showed agreement with published in vivo data while capturing individual morphological and kinematic variations. For chronic injury applications, the platform predicted posture-dependent fatigue damage accumulation in the annulus fibrosus during simulated long-duration flight, demonstrating the capability to model tissue degradation over operationally relevant timescales.

CONCLUSION
This human digital twin platform provides a unified computational framework for personalized injury risk assessment spanning bone and soft tissue, acute and chronic timescales, and multiple anatomical sites. The architecture supports diverse military applications including stress fracture risk analysis, load carriage optimization, return-to-duty evaluation, and chronic injury assessment during prolonged equipment use or vehicle operation.

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Thematic 22 : Biomechanics of load carriage and movement

#46728778
Oral Presentation

Holistic Development and Evaluation of a Vertical Load Offset System for an Integrated Head Protection System

BACKGROUND
Headborne equipment (HBE) (e.g., helmets, visors, sensor systems) worn by explosive ordinance disposal (EOD) operators can impose substantial sustained neck loads, contributing to discomfort and fatigue that may degrade task effectiveness. We developed the Vertical Load Offset System (VLOS), a passive exoskeleton intended to transfer a portion of HBE load to the torso while preserving operational mobility.

METHODS
VLOS was iteratively refined using engineering trade studies, manufacturability constraints, and EOD technician feedback. Human evaluation used a within-subject comparison in which trained operators (n=22 male EOD technicians) completed representative tasks in two conditions: full Next Generations Advanced Bomb Suit (NGABS) system with versus without VLOS. Outcomes included assisted donning/doffing time, task completion time, perceived exertion, region-specific discomfort ratings, and usability. Within-subject and between-condition differences were assessed using paired statistical tests selected based on distributional assumptions (i.e., paired t-test, Wilcoxon signed-rank tests, and ANOVA). Benchtop testing quantified load-transfer behavior across key anthropometric adjustment settings to inform and validate a finite element model of VLOS. The validated model was integrated with an anthropomorphic head–neck FEM to estimate posture-dependent changes in neck forces and moments.

RESULTS
Human questionnaire responses showed significant reductions in perceived neck strain while standing ($p=0.027$) and on hands and knees ($p=0.048$); perceived improvement in ability to move from standing to kneeling ($p=0.029$) and to jog on level terrain ($p=0.025$); and a perceived reduction in the weight of the helmet ($p=0.005$) and overall physical exertion experienced ($p=0.032$). Qualitative ratings of pain, soreness, and discomfort decreased in four separate regions in the neck and upper back, and increased slightly on the shoulders.

There was no significant degradation in overall task completion time($p>0.05$). Donning time increased modestly ($\Delta t=2.12s$, $p=0.046$), but all participants were still able to meet the required NGABS assisted donning time of 120 seconds. FEM simulations in upright postures predicted that VLOS offloaded 28% of the weight of the NGABS helmet in the axial direction, making the added load less than that of previous, lighter generations of helmet. Anterior-posterior loads and sagittal plane moments applied by the EOD helmet were reduced by 115% and 108% respectively, meaning loading directions switched directions but were lesser in magnitude. In horizontal orientations representative of half-kneeling or hands-and-knees postures, the VLOS FEM predicted reduced anterior-posterior neck shearing loads of between 18%-40%, depending on VLOS anthropometric adjustment settings.

CONCLUSION
A combined human and computational evaluation supports the system as a promising approach for reducing HBE load burden in EOD relevant use, while emphasizing the need for posture-specific adjustability and continued refinement to mitigate mobility concerns.

MILITARY IMPACT
Reducing HBE load burden can decrease fatigue and musculoskeletal injury risk, enhancing safety and enabling more effective use of helmet-mounted sensors during high-intensity, time-constrained operations.

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Thematic 22 : Biomechanics of load carriage and movement

#46737983
Oral Presentation

How Do We Move? Understanding Movement Strategies Across Military Tasks

BACKGROUND

Military tasks require soldiers to rapidly transition between postures, often while carrying heavy body-borne loads. Although previous work evaluated within-subject changes to whole-body kinematics as a factor of body-borne load, little is known about the impact of personal and load characteristics on between-subject movement strategies. By understanding the differing movement patterns, strategy-specific performance analyses can be performed. Consequently, this study investigated whole-body joint angles across dynamic military tasks to identify movement strategies and the factors that affect them. We hypothesized that personal and load characteristics would impact movement strategy adoption.

METHODS

Whole-body kinematic data were recorded for 63 participants (18 Civilians, 24 Reservists, and 21 Regular Force members (RegForce)) performing military transition tasks using an inertial measurement unit suit (MVN Link, Movella, US; 240 Hz). 3D joint angles were used to identify movement strategies from six movements (prone to kneel, kneel to prone, run to prone, run to kneel, prone to run, kneel to run) across three loads (5.5, 22, and 38 kg) using Isometric Mapping for dimensionality reduction, and Spectral analysis for clustering. Eta squared (η^2) was used to quantify the relative importance of each joint for cluster separation by computing the proportion of variance explained by cluster membership. The impact of military service type and body-borne load on movement strategy adoption was evaluated using Chi-square tests of independence for each sub-movement. Overall trends across sub-movements were identified using Fisher's combined probability test with Cramér's V for effect sizes (Weak: <0.1, Moderate: 0.1-0.3, Strong: 0.3-0.5, Very strong: >0.5).

RESULTS

Spectral clustering identified four to six distinct movement strategies per task. Chi-square tests revealed significant Military Service * Cluster associations across all sub-movements (χ^2 = [349 - 1008], $p < 0.001$), with some clusters being used almost exclusively by one service type.

Similarly, significant Load * Cluster associations are found for all movements (χ^2 = [18.9 - 66.6], $p < 0.005$) except run to prone (χ^2 = 1.45, $p = 0.96$). Fisher's test confirms the consistent existence of service-specific movement strategies (Fisher's = 3826, $p < 0.001$) with large effect sizes (Cramér's V = [0.56 - 0.86]) and load-specific movement strategies (Fisher's = 147.6, $p < 0.001$) to a moderate extent (Cramér's V = [0.14-0.24]) across tasks. Upper-limb kinematics are the main drivers for cluster separation (mean η^2 = [0.16 – 0.23]), with lower-limb and axial skeleton kinematics being weak to moderate separators ($\eta^2 < 0.15$).

CONCLUSION

The strong contribution of upper-limb joint kinematics to cluster separation suggests that weapon management during the transition tasks greatly affects movement strategy. Accordingly, Civilians, Reservists, and RegForces adopt distinct movement strategies. Body-borne load influenced movement strategy selection to a lesser extent, indicating that movement patterns are primarily driven by personal characteristics, with moderate modulations due to load.

MILITARY IMPACT

Identifying dominant movement patterns across military tasks can improve biomechanical analyses by conducting strategy-specific evaluations. These insights into the factors that impact movement strategies can help military stakeholders optimize training and inform equipment design.

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Thematic 22 : Biomechanics of load carriage and movement

#46788518
Oral Presentation

A combined statistical shape modelling and iterative user-feedback design approach to developing curved hard ballistic plates for Australian Army personnel

BACKGROUND

A high prevalence of ill-fitting body armour has been reported for both female and male soldiers, which has been found to impair range of motion, cause discomfort and can hinder their ability to complete operational tasks. Research suggests that shape/form changes to the hard ballistic plate (HBP) component of body armour systems may improve fit, comfort and performance, but this has not been evaluated. Statistical shape models (SSMs) can inform population-based equipment design processes, offering potential for mass customisation to add a degree of personalisation not afforded by traditional design approaches. Therefore, the purpose of this study was to develop a suite of curved HBPs using a SSM and undertake an iterative design approach based upon end-user feedback.

METHODS

A SSM was developed using 3D scans of the torsos of 1233 Australian Army personnel (12% female). The greatest sources of population variance were captured using principal component analysis, from which seven novel torso geometries were and used to develop a suite of curved HBPs. Cluster analyses of torso length and chest breadth was used to develop a sizing approach. Australian Army soldiers (n=27, 44% female) were recruited to provide iterative user feedback on HBP design during dynamic and occupationally-representative tasks. Participants provided feedback on fit, comfort and movement interference via surveys and informal observations across three test sessions. User feedback informed iterative modifications to HBP designs between test sessions.

RESULTS

Seven initial curved HBP designs (iteration one) were developed based on the novel torso geometries. The first iteration, which prioritised anatomical conformity, was associated with good perceived fit but introduced discomfort during dynamic tasks, particularly at the plate corners and upper edges, and gapping in prone positions. Regardless, informal, unprompted feedback from 10 participants indicated a preference for iteration one HBP designs over in-service plates.

Iteration two incorporated a 13 mm offset to account for carrier and soft armour thickness. This reduced superior plate gapping and was preferred by most participants, although inferior corner discomfort persisted. Iteration three then reduced curvature at the inferior corners, and 90% participants reported improved or minimal differences in fit, comfort, and movement interference compared with the second iteration. No further modifiable design features were identified, therefore no further iterations were developed. Feedback was similar between male and female participants across all iterations.

CONCLUSION

Seven curved HBPs were developed via an iterative design approach integrating a SSM and end-user feedback. Three iterations were required before no further design improvements were deemed necessary. Current work is being undertaken to evaluate the effects of the developed suite of curved HBPs on soldier performance, fit and comfort in the laboratory and field.

MILITARY IMPACT

The HBPs developed in this project represent a first step towards evaluating the suitability of curved body armour systems for use within military settings. With further validation and performance testing, curved HBPs could be deployed at scale to enhance performance, fit, comfort, and operational effectiveness in military populations.

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Thematic 22 : Biomechanics of load carriage and movement

#46788986
Oral Presentation

Current Cervical Conditioning Prescriptions Do Not Match Operational Demands in Rotary-Wing Aircrew

BACKGROUND

Military helicopter aircrew are exposed to sustained cervical spine loading during rotary-wing operations, particularly during night vision system use. Conditioning programs commonly prescribe resistance exercises intended to deliver 40 to 60 percent of maximal voluntary contraction (MVC). Whether these prescriptions reproduce operational torque magnitudes and cumulative loading remains unclear

METHODS

Cervical head position and motion were measured, relative to trunk and airframe, using inertial sensors during an operational daytime sortie. Sensor data were processed through a validated modelling pipeline in OpenSim to calculate joint moments at the seventh cervical vertebra. Data were analysed across pilot, co-pilot, and rear aircrew positions. Helmet configuration and mass properties of the Gentex 56P were incorporated into all load estimations. Operational exposure was quantified as mean and peak resultant moment in newton metres and cumulative load expressed in kilogram-force minutes. Current recommended conditioning prescriptions were aggregated, and corresponding external moments at C7 were derived from single-tube resistance values at 100 percent elongation using a 0.20 metre lever arm. Cervical maximal voluntary contraction values were obtained from 231 helicopter aircrew using dynamometry. Descriptive comparisons were made between operational exposure and recommended training intensity prescriptions.

RESULTS

Mean cervical moment at the seventh cervical vertebra, in flight, ranged from 18 to 21 newton metres (mean 19.6 Nm, 95 percent confidence interval 18.8 to 20.4 Nm). Relative to measured single-plane MVC torques, the mean in-flight resultant moment at C7 (19.6 Nm) corresponded to approximately 41% of extension MVC and 53% of flexion MVC (and 65–69% when compared with lateral flexion and rotation MVC values). Peak moments frequently exceeded 60 percent of maximal voluntary contraction. Cumulative operational exposure during a typical sortie exceeded 180 kgf·min at the seventh cervical level, equating to more than 550 black-band repetition equivalents per week under a three-sortie schedule. In contrast, single elastic tubing at 100 percent elongation generated 3 to 10 newton metres of external moment, corresponding to approximately 10 to 35 percent of maximal voluntary contraction. Although prescribed weekly training volume of 540 repetitions approximated operational repetition equivalents numerically, the external moment per repetition was substantially lower than sustained in-flight loading.

CONCLUSION

Routine helicopter operations impose cervical moments commonly within or above the 40 to 60 percent maximal voluntary contraction range. In contrast, resistance band conditioning prescriptions generate only 3 to 10 newton metres per repetition at equivalent lever arm geometry. Sustained operational intensity is therefore approximately two to three times greater than the torque delivered per prescribed repetition.

MILITARY IMPACT

In high-intensity rotary-wing operational environments, cumulative cervical exposure expressed in kilogram-force minutes may exceed the stimulus delivered by standard conditioning protocols. Underestimation of operational intensity may contribute to under-conditioning, neck pain, and degraded aircrew performance. Objective calibration of resistance prescription using verified percent maximal voluntary contraction targets and torque-based load metrics may improve musculoskeletal resilience and operational readiness.

AUTHORS

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Thematic 22 : Biomechanics of load carriage and movement

#46806257
Oral Presentation

Musculoskeletal Modeling Reveals Individual Variation in Biomechanics of Heavy Load Carriage

BACKGROUND
Military service members are prone to injury, with many leg and spine injuries attributed to load carriage. Internal joint mechanics cannot be measured directly but are critical to understanding injury risk, mechanisms, and mitigation. Musculoskeletal modeling can overcome this limitation, but applying models to individuals, who each have unique tissue properties, posture, movement patterns, and muscle strengths, is challenging. Through multiple studies, we have developed and used a detailed musculoskeletal model of the lower limbs and lumbar spine, combined with a model of a military backpack, to predict internal loads. In addition, individual measurements of body mass distribution, joint-level muscle strength, and individual movement patterns have revealed sources of variation and quantified accuracy in modeling individuals.

METHODS
A full-body musculoskeletal model with 31 degrees of freedom and 288 Hill-Type musculotendon actuators was developed and validated with measurements from 16 military service members. Participants completed a protocol including dual-energy x-ray absorptiometry, 8 maximum isometric strength tests of the lower limb and torso, and multiple walking loaded conditions with added loads and varied terrain. Using optical motion capture and ground reaction forces, walking simulations were developed from the inverse kinematics solution. Computed muscle control was used to determine the muscle recruitment solutions (OpenSim). Simulation quality was ensured with low residual errors, validated relative motion between the backpack and the person, and high levels of agreement with measured electromyography signals for 11 right-side muscles. Models were personalized in size, body mass, body mass distribution, and joint-level muscle strength. The effects of mass distribution and strength personalization on simulation accuracy was evaluated. We calculated joint contact forces as metrics of injury risk.

RESULTS
The modeling framework effectively reproduced measured motion and muscle excitations with low residual errors, demonstrating the utility of this modeling approach to assess internal mechanics for military load carriage. Low back loading increased with the addition of a 40%BW backpack. Attachment of a hip belt was effective at reducing spinal loading, but only when walking downhill. When walking uphill, muscle compensations from the hip flexors counteracted the offloading benefits of a hip belt. Individual mass distribution personalization affected spinal load computations but did not affect the lower limb joints. Lower limb strength scaling from isometric strength tests improved accuracy with measured EMG signals, and substantially influenced joint load estimates, suggesting that personalized modeling is important for revealing injury risk of individual service members.

CONCLUSION
This work quantified internal biomechanics during military load carriage, quantifying a key contributor to predicting injury. In addition, personalization of the models demonstrated variation across participants, providing insight into relative injury risks between participants and how these injuries may be mitigated through technology development and training approaches.

MILITARY IMPACT
Personalization of musculoskeletal models using non-invasive measurements improves accuracy and reveals biomechanical variation that is important to injury risk. Musculoskeletal simulation can identify who is at the greatest risk for injury, and potential pathways to encourage healthy movement and load carriage strategies in a broader population.

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Thematic 22 : Biomechanics of load carriage and movement

#46408775
Poster Presentation

Effect of walking with an active ankle exoskeleton on lumbar biomechanical responses

BACKGROUND
Musculoskeletal injuries pose a health threat to U.S. Service members. In particular, the physical demands of walking and running with load carriage contribute to a high incidence of musculoskeletal injuries of the lower back. Active ankle exoskeleton devices represent promising technologies that may help mitigate the impact of load carriage on the incidence of these injuries. However, the safe extended use of these devices requires an understanding of their beneficial or detrimental effects on the lumbar spine. In this pilot study, we investigated the impact of walking with an ankle exoskeleton device on lumbar biomechanical responses.

METHODS
We collected motion-capture data from five young, healthy men performing a 5-km walking trial at a speed of 1.3 m/s while carrying a 22.7-kg (50-lb) load, both with and without wearing an active ankle exoskeleton (ExoBoot EB60). For each condition and two distances (0 km and 5 km), we developed individualized musculoskeletal and finite-element models to characterize the effects of walking distance and ExoBoot use on the trunk flexion angle, joint reaction force at the L4-L5 joint, and stress on the L4-L5 intervertebral disc annulus.

RESULTS
While not statistically significant, we found that the peak trunk flexion angle and the peak annulus stress increased by 16% and 12%, respectively, after walking 5 km with the ExoBoot and by 34% and 25%, respectively, without it. Similarly, the peak L4-L5 joint reaction force minimally increased by 4% with the ExoBoot, while it increased by 22% without it [1]. We attribute the reduction in lumbar biomechanical responses with the ExoBoot to lower energy expenditure and a more upright trunk posture.

CONCLUSION
ExoBoot use likely attenuates the effect of fatigue on the lumbar spine induced by walking with load carriage.

MILITARY IMPACT
The knowledge gained in this study shall provide initial guidelines for the safe and effective use of the ExoBoot in extended military operations. Reference [1] J.E. Rubio, J. Tong, A. Pant, S. Nagaraja, M.K. Owen, M.A. Samaan, B. Noehren, and J. Reifman. Frontiers in Bioengineering and Biotechnology 13: 1654585, 2025.

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Thematic 22 : Biomechanics of load carriage and movement

#46485020
Poster Presentation

Physiological and Subjective Responses to Heavy Load Carriage Systems: Informing Design Direction in a High-Load Operational Unit

BACKGROUND

Certain military units routinely conduct missions requiring prolonged carriage of loads exceeding 40 kg, imposing substantial physiological and musculoskeletal strain. Within one such unit, differing soldier preferences regarding existing backpack systems have prompted debate over optimal future design. This pilot evaluation combined physiological and user experience measures to guide equipment decisions.

METHODS

Five trained combat soldiers from a unit with high load carriage demands completed controlled laboratory evaluations under standardized environmental conditions. Three backpack systems were tested while carrying identical 40 kg loads: two commercially available adjustable systems designed to stabilize the load, and one locally developed rigid-frame system positioning the load higher and closer to the body's center of mass. Total system mass ranged from 41.8 to 46.2 kg. Participants completed three consecutive 5 minute walking stages at 4.5 $km \cdot h^{-1}$ with inclines of 5%, 10%, and 15%. Heart rate was monitored continuously, metabolic cost was measured using wearable indirect calorimetry, and perceived exertion (Borg RPE) was recorded at each stage. Post test questionnaires assessed comfort, stability, and localized shoulder and hip discomfort. Testing order was randomized with ≥75 min recovery between trials.

RESULTS

Physiological strain increased with workload across all systems. Mean oxygen consumption rose from 21.7 to 32.8 $ml \cdot kg^{-1} \cdot min^{-1}$ between 5% and 15% incline, with heart rate increasing from 110 to 130 bpm. Differences between systems were most pronounced at 15% grade. At 15% incline, the rigid-frame system elicited the lowest physiological strain, with VO_2 ~14% lower and heart rate 8 bpm lower than the highest-demand system, despite having the greatest total mass. RPE increased from 3 at 5% incline to 7 at 15% incline, with consistently lower values observed for the rigid-frame system.

The adjustable systems demonstrated modestly higher comfort and stability ratings (3–4/5 vs. 3/5) and slightly lower shoulder and hip discomfort scores. One adjustable system was preferred by 4 of 5 participants despite higher physiological demand.

CONCLUSION

This pilot evaluation demonstrates the value of combining physiological measures with user experience to address operational equipment decisions. Load positioning closer to the center of mass may reduce physiological strain, whereas ergonomic adjustability strongly influences comfort and user preference. Effective system design must balance load positioning with ergonomic adaptability.

MILITARY IMPACT

In units with extreme load carriage demands, optimizing load carriage systems is critical for mission effectiveness. These findings support development of adjustable platforms that improve load positioning while preserving ergonomic fit. Future prototypes will undergo similar evaluation in larger samples to support evidence-based procurement and force protection decisions.

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Thematic 22 : Biomechanics of load carriage and movement

#46681252
Poster Presentation

Influence of Equipment Configuration and Perceived Fit on Soldier Fatigue During Rucksack Marching

BACKGROUND

Equipment configuration and load distribution influence gait mechanics, metabolic cost, and fatigue development during rucksack marching. Ratings of fit, comfort, and fatigue may reflect differences in body–equipment interaction. The Canadian Armed Forces (CAF) is evaluating a modular load-carriage system through the Dismounted Infantry Enhancement Capability (DICE) initiative, creating a need to evaluate alternative equipment configurations. The present study examined whether ratings of perceived fit and comfort could differentiate between load carriage systems and predict fatigue development.

METHODS

Sixteen CAF soldiers (9M, 7W) with load carriage experience completed four sessions of two 10-minute treadmill marches (with and without ballistic plates) at a standardized cadence of 108 steps per minute across four distinct equipment configurations. The four loaded configurations used the current CAF body armour with the standard in-service rucksack (CTS; total weight ~45 kg), and the DICE rucksack with three configurations (plate carrier (PC) alone, or PC with chest rig or battle belt: total weight ~41 kg). All rucksacks had a 25 kg load with consistent center-of-mass placement. To reduce variability due to improper equipment sizing, subject matter experts ensured equipment fit for each participant by selecting appropriately sized rucksack and rucksack components (e.g., shoulder straps, hip belts). Fatigue was assessed at 5 and 10 minutes using a 20-cm visual analog scale (VAS). Perceived fit and comfort were rated post-march using a 10-cm VAS. Values were expressed as a percentage of the total scale length for analysis. Linear mixed-effects models estimated the association between perceived fit/comfort and fatigue (fit/comfort, time, plate presence, configuration, and total weight as fixed effects; participant as a random effect) and examined differences in perceived fit/comfort across configurations. Tukey-adjusted post hoc pairwise comparisons were conducted following significant main effects. Effect sizes (Cohen's d) were calculated for within-subject comparisons.

RESULTS

Post hoc comparisons showed that all DICE configurations had higher perceived fit and comfort than CTS (mean differences 4.56–4.81%; 95% CI 3.91–5.48%; all $p < 0.001$; $d = 0.58–0.87$). Total system weight was not significantly associated with perceived fit and comfort. No differences were observed between DICE configurations ($p \geq 0.78$). Perceived fit and comfort were inversely associated with fatigue ($\beta = -0.39$; 95% CI −0.55 to −0.23; $p < 0.001$), corresponding to ~1.2% higher VAS fatigue per 10% decrease in fit and comfort. Fatigue also increased over time ($p < 0.001$) and with ballistic plate presence ($p < 0.001$).

CONCLUSION

Perceived fit and comfort were inversely associated with fatigue, and DICE configurations demonstrated consistently higher ratings than CTS. These findings suggest that optimizing body–equipment interaction may reduce fatigue development during load carriage and support more efficient walking mechanics during rucksack marching.

MILITARY IMPACT

Simple subjective measures of perceived fit and fatigue can support large-scale evaluations of load carriage systems. Integrating user-reported fit into equipment development and procurement processes may help identify configurations that reduce fatigue and enhance operational mobility.

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Thematic 22 : Biomechanics of load carriage and movement

#46699021
Poster Presentation

Specific strength training modulates lower limb landing biomechanics in military personnel

BACKGROUND

The lower limbs are frequently over-loaded segments of the musculoskeletal system in military personnel, particularly during drop landings, whether with or without a carried load. Repeated exposure to these loads may alter movement biomechanics and increase the risk of non-contact musculoskeletal injuries. A specific strength-based training program focused on developing lower-limb muscle strength and neuromuscular control may improve attenuation of landing forces and landing mechanics. This study experimentally evaluates the impact of a 6-week specific strength training program on lower-limb movement control during drop landing. The program was designed to be feasible in military field conditions without a need for a gym or specialised equipment.

METHODS

Sixty-three volunteering soldiers (mean age=29.5, SD=6.8 years; mean height=180.7, SD=7.1 cm; mean body mass=85.7, SD=11.3 kg) were allocated to an intervention group (n=44) or a control group (n=19). They performed a series of drop-landings from 50 and 75 cm heights, with and without a carried load (21.45 kg), before and after a six-week intervention. Primary drop landing measures were peak vertical ground reaction force and knee flexion angle. The intervention group completed a six-week strength training program (three times a week) focused on unilateral and bilateral closed-kinetic-chain exercises and landing mechanics drills. During the intervention, ballistic vests and backpacks (0-40 kg) were used as added weights, with progressive overload applied throughout. In contrast, the control group engaged in routine military activities without any systematic strength training. The study was approved by the institutional review board. The alpha level was set at $p \leq 0.05$, and the minimum detectable between-group effect size was estimated at $d \geq 0.91$ with 80% power.

RESULTS

Using linear mixed-effects models, a statistically discernible group-by-time interaction was observed for peak vertical ground reaction force and knee flexion angle. Collapsed across drop heights and loading conditions, peak vertical ground reaction force decreased by 16.7% (Δ = −1153.7 N; 95 % CI [−1262; −1045.1]; $p < 0.001$; $d = 1.28$), while knee flexion angle increased by 6.3% (Δ = −6.11°; 95 % CI [−7.15; −5.06]; $p < 0.001$; $d = 0.71$) in the intervention group. No statistically discernible PRE–POST changes were observed in the control group.

CONCLUSION

The six-week field-based strength program effectively enhanced shock-absorption mechanisms by increasing knee flexion, regardless of the load carried. This shift toward a softer landing demonstrates that targeted field training can alleviate high-impact forces and potentially reduce non-contact injuries during operational tasks.

MILITARY IMPACT

This study shows that field-based, no-equipment exercise programs can be effective and demonstrates feasibility for large-scale implementation in environments with limited access to gym equipment. Integrating structured, field-based neuromuscular training into military conditioning is an effective strategy to improve force attenuation and preserve the operational readiness of personnel subjected to repetitive landing loads.

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Thematic 22 : Biomechanics of load carriage and movement

#46738136
Poster Presentation

Novel Approaches to Soldier Susceptibility Assessments: A Preliminary Analysis

BACKGROUND

While body armour (BA) is important for protecting against ballistic injury and bodily harm, it can negatively affect a soldier's movement performance. Notably, it can affect the range of motion and speed of execution during tactical movements, thereby increasing a soldier's susceptibility to ballistic threats. Technological advancements such as 4D body scanning and markerless motion capture are facilitating the comprehensive evaluation of BA design and its relationship with soldier susceptibility. The current work leverages 4D body scanning technology to assess exposure area to ballistic threats, and markerless motion capture to assess the shoulder check area (SCA) and transition speed between shooting postures.

METHODS

Whole-body kinematic data were collected from 16 participants (9M, 7F) performing transition movements (stand to kneel, stand to prone, kneel to prone, prone to kneel, kneel to stand, prone to stand) using a 4D body scanner (Move4D, IBV, Spain; 60 Hz) time-synchronized with markerless motion capture (Theia3D, Canada; 60 Hz). Participants performed all tasks under 11 conditions, examining both the current Canadian Armed Forces Clothe-the-Soldier (CTS) and the recently acquired Dismounted Infantry Capability Enhancement (DICE) BA. Current analyses focus on base BA configurations and a baseline (slick) condition. The 4D data were used to compute the exposure area in the frontal plane throughout the transition movements. Markerless data were used to segment longer tactical tasks into smaller transition movements from which SCA, measured as the total surface area observed before changing postures, and transition time can be computed. Generalized linear mixed models (Metric ~ Condition * (1|Participant)) were used to evaluate the effect of BA on each metric. Intraclass correlation coefficients (ICC) were calculated to quantify the proportion of total variance attributable to between-subject differences.

RESULTS

Equipment configuration affected SCA ($p < 0.05$), with a larger decrease in SCA with the CTS (18.75 m2) than the DICE (19.13 m2) base BA relative to baseline (20.45 m2). Individual differences accounted for ~35% of the variance in SCA scores (ICC = 0.35), indicating that a moderate portion of the variability stems from participant-specific movement patterns rather than BA configuration. Exposure area and movement time did not differ significantly with the base BA ($p > 0.54$ and $p > 0.07$, respectively). Small between-subject differences were found for exposure area (ICC = 0.14) and movement time (ICC = 0.05).

CONCLUSION

The present investigation displays the feasibility of combining 4D body scanning and markerless motion capture to quantify soldier susceptibility metrics in realistic transition movements. The presence of moderate between-subject variability in SCA suggests that movement strategies may be driven in part by personal characteristics (e.g., military experience, anthropometrics, etc.). Analyses are ongoing, with all conditions expected to be processed and analyzed by the time of the congress.

MILITARY IMPACT

The implementation of emerging biomechanical tools in military research can lead to robust workflows that investigate the effect of BA designs on the integrated survivability tradespace. Notably, the development of novel metrics to quantify susceptibility to ballistic threats presents a foundational step towards understanding trade-offs between protection and mobility stemming from BA design.

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Thematic 22 : Biomechanics of load carriage and movement

#46738235
Poster Presentation

Evaluating Military Equipment Configuration During Rucksack Marching

BACKGROUND

Soldiers must alter their whole-body kinematics when marching with heavy backpack-borne loads to counteract the increased gravitational forces and distal shift of the centre of mass. Notably, increased forward trunk lean, cadence, stride length, stride rate, and stride width can be observed during rucksack marching. Rucksack and body armour form (i.e., the physical shape of the equipment) can modulate the negative effects of heavy load carriage by minimizing load-related postural and mobility changes. As Canada modernizes its equipment through the Dismounted Infantry Enhancement Capability (DICE) initiative, a much more modular set of equipment, investigating the kinematic effects of various body armour-rucksack configurations can help determine optimal equipment configurations.

METHODS

Whole-body kinematic data were obtained from 16 members of the Canadian Armed Forces (CAF; 9M, 7F) during rucksack marching on a treadmill using a markerless motion capture system (Theia3D, Canada; 100 Hz). Participants completed one baseline unloaded march and three sessions of two 10-minute marches with varying equipment configurations. The three loaded configurations used the DICE rucksack worn over DICE fighting order, comprising one of three body armour configurations: plate carrier only, plate carrier with chest rig, or plate carrier with battle belt. External equipment load was held constant (10 kg in body armour, 25 kg in rucksack), and centre of mass location was constant across pack configurations. Local dynamic stability, as well as the mean and standard deviation (SD) of stride time, stride width, double-support time and percentage, step length, trunk sway, trunk lean, and cadence, were computed over 150 strides to quantify gait quality. Linear mixed-effect models with false discovery rate correction were used to determine the univariate effect of equipment configuration on each metric. The mean absolute effect size (paired Cohen's d) across all statistically significant metrics was obtained for each equipment configuration to quantify gait disruption.

RESULTS

A significant effect of equipment on gait kinematics was found for double support percentage, stride width SD, trunk lean and sway mean and SD, as well as trunk sway mean and SD, with all FDR-adjusted p-values < 0.05. Gait disruption was largest for the plate carrier with chest rig configuration ($d = 1.36$), followed by the plate carrier with battle belt configuration ($d = 1.26$), with gait patterns in the plate carrier only configuration being least affected ($d = 1.13$).

CONCLUSION

The chest rig is thought to be most disruptive to gait patterns because the added ventral bulk forces participants to adjust their riffle holding posture while rucking. Conversely, the battle belt elevated the ruck's load and centre of mass, as it was placed atop the rucksack so that users could properly fit the rucksack's hip belt. Overall, load placement and centre of mass can meaningfully disrupt gait patterns, which may affect fatigue and musculoskeletal health, negatively impacting operational readiness and mission success.

MILITARY IMPACT

Understanding how equipment configuration influences gait kinematics can help inform future equipment designs to minimize gait disruptions. The rigorous testing of Canada's new equipment can help identify the optimal rucksack-marching configuration that least impedes a soldier's natural gait pattern.

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Thematic 22 : Biomechanics of load carriage and movement

#46766919
Poster Presentation

Development of a Tool to Evaluate the Effect of Headborne Equipment and Fatigue on Warfighter Burden

BACKGROUND
The added mass of personal protective equipment can negatively affect warfighter injury risk and performance. In particular, headborne equipment (HBE) influences neck mechanics, marksmanship performance, and neck pain. These negative effects are amplified by muscle fatigue induced by HBE. This indicates that the effect of HBE mass properties and fatigue on musculoskeletal (MSK) burden are important to consider in the design and evaluation of HBE. The objective of this work was to develop a software tool to evaluate MSK burden caused by HBE and fatigue, while incorporating relevant variations across warfighters.

METHODS
A previously-validated MSK model was adapted for this software tool. This model was scaled to the statures, weights, and strengths of a 50th percentile female and male. Variations in neck muscle strength from a 5th percentile female to a 95th percentile male were enabled using neck strength of healthy individuals. A model of HBE with variable mass properties was rigidly attached to the skull. A model of muscle fatigue was incorporated into the MSK model and calibrated using neck fatigue data. This allowed for modeling of neck muscle fatigue due to HBE. Simulations of walking, running, and prone were implemented using previously collected data. These models were then integrated into a software tool and used to investigate the effects of HBE mass properties and fatigue during simulated walking. HBE mass was varied from 1kg to 4kg and the center of mass (CoM) was varied from 2 cm posterior to 10 cm anterior to the head CoM. Four levels of fatigue were simulated (none, mild, moderate, and severe). Peak force and impulse at the T1-C7 joint were compared across simulations.

RESULTS
The developed software tool enables assessment of the effect of HBE mass properties, muscle fatigue, stature, strength, and activity on neck mechanics. Increasing HBE mass and shifting the CoM anterior increased the peak force and impulse at T1-C7. Increasing HBE mass had a slightly greater increase in T1-C7 impulse for the female model than the male (35% and 31% for the female and male, respectively). Shifting the CoM anterior had a greater increase in T1-C7 impulse for the female than the male (29% and 5% for the female and male, respectively). Fatigue increased peak force and impulse at T1-C7 with severe fatigue having a greater effect on the T1-C7 impulse for female than the male (21% and 16% for the female and male, respectively).

CONCLUSION
Fatigue has an effect on neck mechanics that is comparable to that of HBE mass and CoM, with these effects varying across the female and male models. This indicates that fatigue, in addition to HBE mass and CoM, should be considered in the design and use of HBE.

MILITARY IMPACT
This tool can support armor acquisition and design to provide a risk assessment for HBE. These results indicate that HBE mass properties, variations across warfighters, and mission duration should be considered in guidance for HBE.

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Thematic 22 : Biomechanics of load carriage and movement

#46783598
Poster Presentation

Impact of pitch motion on manual pulling performance and postural stability : Implications for naval operability

BACKGROUND
Naval personnel operate in inherently unstable environments where ship motions, such as pitch and roll, continually challenge postural balance. In the context of high-intensity conflicts, crew members must perform physically demanding tasks – such as operating heavy valves for damage control or handling ammunition – while the platform is in continuous motion. While the biomechanical effects of static floor inclinations are documented, the specific impact of continuous dynamic motion on maximal force production remains unquantified. This study characterizes how pitch motion affects maximal pulling force, ground reaction forces (GRFs), and postural adjustments to better anticipate operator limitations in rough seas.

METHODS
Twenty-eight active-duty naval personnel (13 females, 15 males; age: 26 ± 5 years) participated in this study. Participants performed maximal isometric one-handed pulling tasks while bracing with the non-task hand on a vertical surface. The experiment was conducted on a hexapod motion platform under two main conditions: a static horizontal reference and continuous sinusoidal pitch motion (± 7° amplitude). The dynamic condition was tested at two periods: 12 s (slow) and 6 s (fast). Pulling force, GRFs under each foot, and whole-body kinematics were recorded. Data were analyzed at key motion cycle events (horizontal transition, peak forward/backward inclination) using mixed-design repeated-measures ANOVAs ($p<0.05$).

RESULTS
The presence of continuous motion significantly degraded physical performance. Even when the platform momentarily passed through the horizontal position (0°), maximal pulling force decreased by approximately 12% compared to the static reference ($p<0.001$). This deficit was exacerbated at peak forward inclination (+7°), reaching a 15% force reduction ($p<0.001$). Force loss was less pronounced at peak backward inclination (7% reduction; $p<0.05$). No significant difference was found between the slow and fast motion speeds ($p>0.05$).

Biomechanical analysis revealed that operators adopted complex strategies, significantly transferring body weight onto the bracing hand and redistributing GRFs towards the ipsilateral foot ($p<0.001$), particularly during forward inclinations, prioritizing stability over force production.

CONCLUSION
Continuous pitch motion acts as a distinct limiting factor for manual performance, imposing a "stability cost" that compounds the effect of inclination. Even with manual bracing, the neuromuscular system prioritizes postural regulation, reducing the resources available for the primary pulling task. Current ergonomic models based on static data likely overestimate sailor capabilities in real-world sea conditions.

MILITARY IMPACT
In high-intensity naval warfare, ship survivability often depends on the crew's ability to rapidly execute physical interventions (e.g., closing watertight doors to prevent fire propagation) in rough seas. This study demonstrates that dynamic instability reduces operator physical capacity by up to 15%. Therefore, risk assessments and the design of critical workstations must account for this motion-induced deficit to ensure that physical interfaces remain operable by the crew during combat scenarios, guaranteeing both safety and operational efficiency.

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Thematic 22 : Biomechanics of load carriage and movement

#46802370
Poster Presentation

A musculoskeletal modelling approach to estimate soldier biomechanical load during load carriage (a preliminary study)

BACKGROUND
During multi-day missions, soldiers often need to carry substantial loads, including weapons, protective equipment, camping gear, and food. Prolonged exposure to such loads can negatively affect performance and might increase the injury risk. Quantifying the effects of load carriage on musculoskeletal tissues is, however, challenging because in vivo measurements are not possible with the current technological solutions. A musculoskeletal modeling approach provides valuable insights into the biomechanical load on the musculoskeletal tissues of the individual soldier. Aim: To demonstrate a proof-of-principle how a musculoskeletal modelling approach can be used for estimating the biomechanical load of musculoskeletal tissues during load carriage.

METHODS
One participant (male, 74 kg, 178 cm) walked on two speeds (4 and 6 km/h) and in two configurations (without, with 20kg backpack). At the military rehabilitation center Aardenburg, an optical motion capture system (Nexus, Vicon) and instrumented treadmill were used to collect kinematic and kinetic data. In OpenSim (version 4.5), a generic model (with lower body muscles) was scaled to the dimensions of the participant. Inverse kinematics was performed to map the marker data to the scaled OpenSim model and generate a walking movement. Consequently, inverse dynamics was performed to quantify the joint moments required for the specific movement.

RESULTS
Ground reaction forces increased with speed and with additional weight. Furthermore, joint moments were higher during walking with backpack and during increased speed walking.

CONCLUSION
This case study demonstrates the potential of in silico approaches to address challenges in the military domain. Future research should establish internal biomechanical load metrics (joint contact forces, muscle forces) that are informative for injury risk assessment. Furthermore, additional walking conditions or more operationally relevant movements (e.g., jumping or running) might be included in future analyses.

MILITARY IMPACT
In silico approaches provide insights in the biomechanical demands of load carriage. The results can serve as input for guideline development, performance optimization strategies, and injury risk prediction. Moreover, these outcomes can be integrated into a digital representation of the soldier (digital twin), which can be used for virtual evaluations of clothing and equipment, route optimization or mission planning.

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Thematic 22 : Biomechanics of load carriage and movement

#46808153
Poster Presentation

The effect of load carriage on task relevant and task equivalent gait fluctuations in male and female soldiers

BACKGROUND
Load carriage is fundamental to military operations, but it increases risk of musculoskeletal injury, and the risk can be up to four times greater in female than male soldiers. Gait variability can provide an indication of how the neuromotor system adapts to changes in operational constraints and maintains stability during physically-demanding tasks. Understanding how carrying load influences gait variability and how these responses differ between sexes would help optimise soldier readiness and reduce injury risk.

METHODS
Twenty three Australian Army soldiers (11 female, 12 male) completed nine 12 minute treadmill walking trials at three speeds (3.5, 5.5, 6.5 $km \cdot h^{-1}$) under three absolute load conditions (7.2, 23.2, 35.2 kg). Goal-equivalent manifold (GEM) analysis was performed to assess how gait variability was regulated to maintain the task goal of walking at the constant treadmill speed. GEM analysis differentiates task-relevant gait fluctuations, which directly impact the task goal, from task-equivalent fluctuations that do not. Linear mixed models evaluated the fixed and interaction effects of load, sex, and speed on GEM outcome variables.

RESULTS
Greater loads significantly reduced relative variability (the ratio of task equivalent to relevant fluctuations – $p = 0.004$), driven by decreased task-equivalent, and increased task-relevant, fluctuations. Female soldiers demonstrated greater task-equivalent and lower task-relevant fluctuations than males, resulting in a higher relative variability ($p = 0.037$), along with reduced persistence in task-relevant fluctuations ($p = 0.001$), suggesting tighter regulation of task-relevant gait variability. Speed did not moderate the effects of load or sex on any GEM outcome variable.

CONCLUSION
Greater external load reduced the extent to which equivalent motor solutions were expressed, suggesting participants de-prioritised the task of maintaining constant walking speed. It is possible that they instead prioritised competing locomotor demands, such as maintaining balance and stability, or managing energic cost, when carrying load. The differences between female and male soldiers suggest that females, although responding to changes in load in a similar way to males, showed greater relative variability across all loads. This might reflect a greater need for female soldiers to prioritise the task of walking at a constant speed, and that this could be associated with the absolute loads prescribed in each load condition.

MILITARY IMPACT
GEM based gait variability metrics could help identify individuals who experience greater neuromotor challenge during load carriage. These measures could support targeted load carriage training and inform operational readiness assessments, ultimately reducing injury risk and incidence.

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Thematic 22 : Biomechanics of load carriage and movement

#46809689
Poster Presentation

Musculoskeletal modeling of the soldier: application to the biomechanical study of load carriage for five movements typically encountered during a mission

BACKGROUND

Operational load carriage induces chronic musculoskeletal disorders (MSDs) among soldiers, specifically targeting the spine and lower-limb regions. Biomechanical modeling and analysis enable the quantification of muscle forces and joint constraints, which reflect the musculoskeletal demand imposed by load carriage and help explain injury onset mechanisms. However, the estimation of muscle forces must be rigorously validated against experimental muscle activation with electromyography (EMG) data to ensure physiological fidelity across varying load conditions. This study evaluates a full-body musculoskeletal model with experimental data from active French soldiers performing operationally relevant movements under various loading conditions.

METHODS

Fourteen participants (13M/1F) were instrumented with optical markers and 16 surface electrodes for synchronized kinematic and EMG data collection. Participants performed five to six repetitions of five representative infantry movements: walking, running, jumping, change of direction, and obstacle crossing, while reaction forces were recorded. Four loading conditions were evaluated: unloaded, LB (11.7 kg), HB (17 kg), and PB (ballistic protection with backpack, 24 kg). This study was approved by the National Ethics Committee (CPP No. 2024-A02738-39). The CusToM toolbox was employed to estimate muscle forces via static optimization. To ensure reliability, these estimates were compared to EMG signals using cross-correlation, and load-dependent trends were evaluated via ANOVA (Kruskal-Wallis) tests with a significance level of p= 0.05. Initial processing focused on walking, as it represents the most studied movement in military load-carriage research.

RESULTS

Strong correlations ($r > 0.7$) were observed between muscle forces and EMG signals for most instrumented muscles, alongside consistent trends across different loading conditions. The mean correlation coefficient exceeded 0.7 for the trunk and lower limb muscles, except for the gluteus maximus ($r = 0.679 \pm 0.245$).

Regarding trends with load carriage, both EMG and estimated muscle forces increased significantly compared to the unloaded condition: for the iliocostalis at LB and HB ($p \leq 0.012$), the longissimus at PB ($p < 0.001$), the multifidus at LB and HB ($p < 0.001$) and the rectus abdominis for all loads ($p < 0.001$). Similar increases occurred for the vastus medialis, the gastrocnemius and the gluteus maximus ($p < 0.001$) in all conditions. However, the biceps femoris showed a discrepancy: although estimated forces increased significantly, measured EMG decreased (minimal effect size, $\varepsilon^2=0.0427$). Muscle forces increased proportionally to the load, reaching 221% for the trunk and 145% for the lower limbs under PB conditions (LB: 164% and 61%; HB: 212% and 84%, respectively).

CONCLUSION

This study provides initial evidence validating muscle forces trends against experimental EMG during loaded gait. While simulations and experimental data showed strong similarities, discrepancies in the gluteus maximus and biceps femoris may stem from static optimization assumptions. Subsequent work will focus on evaluating the remaining recorded mission-specific movements.

MILITARY IMPACT

Integrating validated musculoskeletal simulations to analyze load carriage in operationally relevant movement offers significant benefits for MSDs prevention, soldier training optimization, and research and development of infantry gear.

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Thematic 23 : Performance at high altitude

Le Grand Salon - P. Fabries + B. Beidleman

ORAL PRESENTATIONS

Impact of Acute Prior Sleep Restriction on Cognitive, Inflammatory and Physiological Responses to Moderate Normobaric Hypoxia

Differential Effects of Moderate Hypoxia on Visual and Auditory Attentional Processes: EEG Evidence and Implications for Prospective Memory

Physical Fatigue Induced by Military Operations in Hypoxic and Cold Environment

Physiological Load, Neuromuscular Performance, Body Composition and Inflammatory Responses During 4 Weeks of US Marine Corps Mountain Warfare Training

Two-mile time trial performance is impacted by moderate/severe but not mild acute mountain sickness at 4,300 m

POSTER PRESENTATIONS

Cognitive Fatigue Induced by Military Operations in Hypoxic and Cold Environment

Seasonal Modulation of Short-Term Adaptations to Moderate Altitude: Comparative Physiological Responses to Arduous Winter and Summer Marine Corps Training

Thematic 23 : Performance at high altitude

#46607992
Oral Presentation

Impact of Acute Prior Sleep Restriction on Cognitive, Inflammatory and Physiological Responses to Moderate Normobaric Hypoxia

The current NATO STANDARD AAMedP-1.3 allows pilots operating unpressurized aircraft to fly without supplemental oxygen for the first 60 min of flight below 3,800 m and for the first 30min of flight below 4,300 m. Pilots, however, are often sleep deprived prior to flight.

The purpose of this research was to identify whether insufficient sleep combined with exposure to moderate normobaric hypoxic (NH) impacts working memory and whether this impact was associated with changes in immunoinflammatory parameters and/or physiologic responses.

Seventeen healthy men (31±7 years) were exposed to 5 h of moderate NH (FIO2=13.6%, 3500m) following one night of either habitual sleep (>6h time in bed; HS) or restricted sleep (≤3h time in bed; SR), using a randomized crossover design. Working memory, related to situation awareness, was evaluated using the N-back task after 30 min of NH exposure. Salivary stress biomarkers (α-amylase [sAA] and cortisol) were measured immediately following the cognitive task. Plasma concentrations of immunoinflammatory cytokines, TNF-α, IL-8, and IL-10, were measured after ~1 h of NH exposure. Ventilatory variables (respiratory rate (RR) and tidal volume (VT)) were assessed after 1.5 h of NH exposure. Peripheral oxygen saturation (SpO2) and heart rate (HR) were monitored continuously during the cognitive task and the mean was calculated.

Accuracy on the 0-Back, 1-Back and 2-Back tasks was lower in SR compared to HS (p=0.018, 0.002 and 0.006), and reaction time was longer (p=0.018, 0.005 and 0.023). sAA (U/mL) was lower (p=0.005) in SR (86.9±11.2) compared to HS (145.4±24.3) but cortisol was similar between conditions. TNF-α (pg/mL) was significantly higher (p=0.012) in SR (0.98±0.38) compared to HS (0.86±0.41) but there was no difference in IL-8 or IL-10 between conditions. SpO2 (%) did not differ between SR (88.1±2.4) and HS (88.1±2.5) but HR (bpm) was higher (p=0.024) in SR (67.7±6.7) compared to HS (65.3±7.8).

Tidal volume (L) was higher (p=0.031) in SR (0.67±0.34) compared to HS (0.63±0.33) after 1.5h of NH exposure. Reaction times on the 1-Back and 2-Back tasks were positively correlated with HR in both the SR (r=0.438-0.614, p=0.079-0.009) and HS (r=0.497-0.710, p=0.043-0.001) conditions.

There were no significant correlations between cognitive tasks and the ventilatory or biomarkers responses. Sleep restriction impairs working memory and exacerbates ventilatory, stress, and inflammatory responses during moderate NH exposure. The decrement in working memory, however, was not related to peripheral oxygen levels.

This research suggests that pilots may consider using supplemental oxygen during the first hour below 3,800m, especially if they are sleep deprived, in order to preserve flight safety. The combined impact of these two stressors must be considered when developing targeted recommendations and countermeasures. A better understanding of the underlying mechanisms could enable these recommendations to be further personalized.

AUTHORS

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Thematic 23 : Performance at high altitude

#46637168
Oral Presentation

Differential Effects of Moderate Hypoxia on Visual and Auditory Attentional Processes: EEG Evidence and Implications for Prospective Memory

BACKGROUND
Operators in unpressurized aircraft continuously monitor visual displays and auditory alarms, placing high demands on attentional systems. In this context, physiological constraints such as reduced oxygen availability alone or combined with sleep restriction are known to impair attention. Visual processing has high metabolic requirements from retina to cortical pathways, while auditory systems may show greater resilience to hypoxia. However, the differential neurophysiological impact of moderate hypoxia on visual versus auditory attentional processes remains poorly defined, particularly regarding EEG markers of temporal integration and phase coherence.

METHODS
Seventeen healthy males (30.9±7.4 years) completed a within-subject crossover with 4 conditions: habitual sleep with normoxia (HSNO), habitual sleep with hypoxia (HSHY, FiO2=13.6%, 3500m equivalent, 4h), sleep restriction with normoxia (SRNO, 3h time-in-bed), and combined constraints (SRHY). EEG was recorded during visual Psychomotor Vigilance Task and auditory oddball task. Analyses included P300 amplitude and latency, alpha event-related desynchronization (α-ERD), alpha inter-trial phase coherence (α-ITPC), and individual alpha frequency (IAF). Statistics used linear mixed models with Holm-corrected post-hoc comparisons.

RESULTS
P300 amplitudes decreased significantly with sleep restriction (SRNO vs HSNO: $p<0.001$) and combined constraints (SRHY: $p<0.001$) for both modalities, but not hypoxia alone (HSHY: $p>0.05$). Critically, visual P300 latency increased under all constraints (HSHY: $p=0.003$; SRNO: $p<0.001$; SRHY: $p=0.005$), whereas auditory latency remained unchanged. Visual α-ITPC decreased significantly under HSHY ($p<0.001$), SRNO ($p<0.001$), and SRHY ($p<0.001$). Auditory α-ERD was impaired by HSHY ($p<0.001$) with no α-ITPC effects. IAF slowed during SRHY (visual: $p=0.04$; auditory: $p<0.001$). Results show modality-specific vulnerabilities: visual temporal integration was more sensitive to moderate hypoxia.

CONCLUSION
Visual processing showed greater vulnerability with delayed P300 latencies and reduced phase coherence. Alpha alterations under oxygen restriction with or without sleep restriction provide insights into the Berger effect, highlighting the functional and context-dependent involvement of alpha oscillations in cognitive functioning. Given alpha's role in controlled access to stored information and excitation-inhibition balance, hypoxia may directly impact prospective memory, a future-oriented memory allowing intended actions at the appropriate moment. Our ongoing research investigates the relationships between hypoxia, EEG modifications and memory processes within a flight simulation environment.

MILITARY IMPACT
These findings have implications for aircrew operating unpressurized aircraft. The impairment of visual temporal processing is concerning for monitoring and threat detection. Preserved auditory P300 suggests acoustic warnings remain reliable. Alpha slowing indicates reduced cognitive preparedness. Understanding how hypoxia alters brain rhythms supporting attention and memory enables targeted interventions. Our prospective memory investigation focuses on the ability to execute actions at appropriate times. Failures in this domain pose significant operational risks. Our findings aim to inform oxygen thresholds and the development of cognitive countermeasures for high-altitude operations.

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Thematic 23 :
Performance at high altitude

#46709600
Oral Presentation

Physical Fatigue induced by Military Operations in Hypoxic and Cold Environment

BACKGROUND
The Arctic environment is characterized by extreme cold and hypoxia which can affect soldiers' physical performance, especially during sustained military operations. The aim of this study was to explore the effects of operating in a hypoxic and cold environment (HCE) on the physical fatigability of three different groups of alpine soldiers.

METHODS
36 soldiers specialized in mountain warfare (Alpine Corp) were tested before, during and after a 3-days military exercise on the Mont Blanc (3375m). Additional tests were conducted at 551m, four days before and 14 days after. Soldiers were divided into three groups, based on their experience and operational role: A (alpine lieutenant), B (alpine special forces), C (alpine specialized guides). Soldiers were tested daily before and after the military exercise session, consisting of basic mountain warfare skills and technical navigation on the glacier. Pre-exercise measures included a 5-min Astrand-Rhyming step test, in which we measured heart rate (HR), perceived leg and breathing effort and blood lactate (BLa) at the 5th min. During the ME we recorded exercise activity with Garmin watches. Post-exercise, soldiers repeated the step test and rated the effort (session RPE) and workload (NASA-TLX) experienced during the military exercise session. We ran mixed models analysis with Gamma or Gaussian distributions depending on data characteristics; data clustered in subjects and selected as random effects intercept. Day, Group and Time treated as fixed factors; Holm-Bonferroni correction for follow-ups.

RESULTS
sRPE ($X^2(4)=61.28$; $p<.001$) and NASA-TLX domains ($p<.001$) were significantly higher in HCE compared to low altitude, confirming that military exercise sessions were perceived as significantly more effortful and physically demanding in HCE. Moreover, significant main effect of Group ($F(2,33)=4.91$; $p=0.014$) and interaction Day*Group ($F(8,131)=2.47$; $p=0.016$) for NASA physical load; follow up detected that group B perceived no difference for physical load in HCE compared to low altitude, in contrast to groups A and C.

All the step test variables deteriorated in HCE (Day $p<.001$) and further increased after the military exercise (Time $p<0.05$). Day*Time was found only for HR ($F(4,308)=4.77$; $p<.001$) and bLA ($X^2(4)=18.35$; $p=0.001$).

CONCLUSION
These results show that even soldiers specialized in mountain warfare suffer from negative effects of HCE, which include higher perceived physical demands during military exercise. We confirmed that hypoxia increased heart rate, blood lactate, perceived leg effort and dyspnea. Moreover, we demonstrated that operating in HCE has further exacerbated those negative effects.

MILITARY IMPACT
This study provides insights on physical fatigability experienced by specialized soldiers when operating in extreme cold and hypoxic environments. Countermeasures to reduce soldiers' physical fatigue, and consequently enhance their performance in HCE, are warranted.

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Thematic 23 : Performance at high altitude

#46781693
Oral Presentation

Physiological Load, Neuromuscular Performance, Body Composition and Inflammatory Responses During 4 Weeks of US Marine Corps Mountain Warfare Training

BACKGROUND

Extended training without workload monitoring puts military personnel at risk for overtraining and maladaptation characterized by decrements in performance, hormonal dysregulation, and increased injury risk. Despite the well-documented physiological demands of operations in austere environments, literature characterizing multifaceted physiological toll of real-world military training environments is sparse. The purpose of this study was to investigate neuromuscular, endocrine, and body composition changes in response to an intensive 4-week Mountain Exercise (MTX) designed to mentally, physically, and technically prepare Marines for operations in treacherous environments, leveraging wearable devices to characterize course-long workload.

METHODS

Forty-seven male Marines (Age:21.6±3.5yrs, BMI:27.1±3.4kg/m2) were assessed via countermovement jump (CMJ), serum hormone concentrations (insulin-like growth factor I [IGF-I], sex hormone binding globulin [SHBG], total testosterone [TT], interleukin-8 [IL-8], IL-10) and body composition Pre/Post MTX. Garmin Instinct watches were worn to quantify internal- and external workload for the course duration. Paired T-tests assessed timepoint differences and Cohen's d was used to calculate effect size. All procedures were approved by the appropriate Institutional Review Boards.

RESULTS

Workload: Mean distance traveled was 9.3±3.8km/d; mean elevation gain of 83.2± 3.6m/d; mean caloric expenditure was 3155.8±533.3kcal/d with 3.1±1.0hrs/d of moderate to vigorous activity. Body Composition: Body mass, lean mass, and fat mass decreased by 6.2% (p<.001, ES=-2.42, 95% CI[-5.93– -4.52kg]), 4% (p<.001, ES=-0.91, CI[-3.74– -1.78kg]) and 15% (p<.001, ES=-0.84, CI[-2.92– -1.30kg]), respectively. CMJ: Concentric mean force, eccentric mean force, and eccentric + concentric power/time decreased by 7.6% (p<.001, ES=-1.06, CI[-157.6– -89.46N]), 5.9% (p<.001, ES=-2.48, CI[-54.17– -42.68N]), and 10% (p=.001, ES=-0.50, CI[-230.33– -60.77W/s]), respectively. Biochem: IGF-I and TT levels decreased by 31.8% (p<.001, ES=-0.96, CI[-39.69– -22.76ng/mL] and 8.8% (p=0.02, ES=-0.5, CI[-15.37– -1.81ng/dL]), respectively, while SHBG levels increased by 41.5% (p<.001, ES=1.00, CI[27.06–57.62 nmol/L]) and inflammatory cytokines IL-8 and IL-10 increased by 12% (p=0.049, ES=0.32, CI[0.01–25.57 pg/mL]) and 18.3% (p<0.01, ES=0.5, CI[6.11–31.80 pg/mL]), respectively.

CONCLUSION

Overall, there was a maladaptive stress response exhibited by decreases in total body mass, lean mass, fat mass, and CMJ force/power production capabilities in conjunction with elevated SHBG and markers of inflammation with a concurrent decline in IGF-I and TT.

MILITARY IMPACT

Understanding the physiological demands of prolonged training operations in harsh environments is vital in planning for sufficient recovery periods in the training pipeline. Appropriate recovery is essential for reducing the likelihood of overtraining syndrome common in military populations.

AUTHORS

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Thematic 23 : Performance at high altitude

#46824678
Oral Presentation

Two-mile time trial performance is impacted by moderate/severe but not mild acute mountain sickness at 4,300 m

BACKGROUND

Unacclimatized Soldiers rapidly exposed to high altitude (HA) experience 55% to 75% decrements in endurance exercise performance. Longer tasks are impacted to a greater degree than shorter tasks. Whether or not symptoms of acute mountain sickness (AMS), which also occur following rapid ascent to HA, impact endurance exercise performance has never been systematically studied. The purpose of this study was to analyze decrements in two-mile time trial (TT) performance following both active and passive ascent to 4,300 m and determine whether the severity of AMS impacts these decrements.

METHODS

Thirty-two healthy Soldiers (mean±SD; age=23±4yr) were tested at baseline residence (BLR, 50-399m), transported to 1,845m and outfitted with physiologic monitors, driven to 3,985m, and hiked (n=16; active) or were driven (n=16; passive) to 4,300 m and stayed for four days. A two-mile TT was conducted at BLR and after 20 hours of HA exposure (HA2). The maximal-effort TT was self-paced and conducted at a 1% fixed grade. Soldiers were blinded to time elapsed during the TT but made aware of distance completed. Peripheral oxygen saturation (SpO2) and heart rate (HR) were recorded continuously during the TT and rating of perceived exertion (RPE) was collected immediately after finishing. The Lake Louise 2018 Questionnaire was utilized to assess AMS. If the Lake Louise Score (LLS) was ≥3 but <6 plus headache, individuals were classified with mild AMS. If LLS was ≥6 plus headache, individuals were classified with moderate/severe AMS.

RESULTS

Active versus passive ascent did not impact TT results so groups were combined. The % decline in TT performance from BLR to HA2 differed in the moderate/severe AMS group (n=4; 69.2±9.2%) compared to the no AMS group (n=13; 45.4±4.5%; p=0.03) and mild AMS group (n=15; 47.4±4.6%; p=0.04). No differences in TT performance occurred between the no and mild AMS groups. The % decline in TT performance was correlated (r=0.38, p=0.03) with LLS severity.

There were no differences in mean SpO2 during the TT between the no AMS group (75.8±1.3%) and mild AMS group (74.4±1.2%) but mean SpO2 tended (p=0.07) to be lower in the moderate/severe AMS group (70.8±2.3%). The % decline in TT performance was correlated (r=-0.48, p=0.001) with mean SpO2. The mean HR (bpm) during the TT was higher in the no AMS (165.5±2.6) and mild AMS groups (157.4±2.4) compared to the moderate/severe AMS group (147.5±4.7; p=0.006) due to maintaining a higher treadmill speed (5.1±0.8 vs 4.3±0.4 mph). The RPE did not differ between AMS groups.

CONCLUSION

This study provides robust evidence that moderate/severe AMS negatively impacts two-mile TT performance. In addition, there appears to be a continuum with more severe symptoms of AMS associated with longer completion times. Individuals that are moderately to severely impacted by AMS lower their working speed during the two-mile time trial, but mild symptoms of AMS do not appear to influence task duration.

MILITARY IMPACT

Preventing AMS, especially moderate to severe AMS, is critical for maintaining operational effectiveness and performance at HA. Medication, pre-acclimatization, staging, and use of ergogenic aids may reduce AMS risk and allow Soldiers to maintain their endurance performance following acute ascent to 4,300 m. Disclaimer: Authors' views not official U.S. Army or DoW policy. Funding: USAMRDC

AUTHORS

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Thematic 23 :
Performance at high altitude

#46728293
Poster Presentation

Cognitive Fatigue induced by Military Operations in Hypoxic and Cold Environment

BACKGROUND
Arctic environments increase soldiers' mental demand and impair their cognitive performance in terms of accuracy and attention. The aim of this study was to explore the effects of operating in a hypoxic and cold environment (HCE) on cognitive functions in alpine soldiers.

METHODS
36 soldiers specialized in mountain warfare (Alpine Corp) were tested before, during and after a 3-days military exercise on the Mont Blanc (3375m). Additional tests were conducted at 551m, four days before and 14 days after. Soldiers were divided into three groups, based on their experience and operational role: A (alpine lieutenant), B (alpine special forces), C (alpine specialized guides). On each day, soldiers were tested before and after the military exercise session consisting of basic mountain warfare skills and technical navigation on the glacier. Pre-exercise measures were Groningen Sleep Quality and Fatigue scales; and 5-min psychomotor vigilance task (PVT). Post-exercise, soldiers repeated PVT and rated perceived workload (NASA-TLX) experienced during the military exercise and their fatigue changes compared to pre-exercise (Fatigability scale). We ran mixed models analysis with Gamma or Gaussian distributions depending on data characteristics; data clustered in subjects and selected as random effects intercept. Day, Group and Time treated as fixed factors; Holm-Bonferroni correction for follow-ups.

RESULTS
PVT reaction time deteriorated significantly post-exercise (Day*Time $X2(4)=21.12$; $p<.001$) only on the first day in HCE (D2-D1*Post-Pre $b=15.18$; $SE=3.64$; CI95%=(8.05 to 22.31); $p<.001$), indicating acute cognitive fatigability. Military exercise was perceived as more mentally demanding in HCE (Day $X2(4)=56.95$; $p<.001$). Also Group significant main effect ($X2(2)=8.14$; $p<.05$) was detected for mental demand; follow-up detected group B perceiving a lower mental demand compared to group A and C. Both fatigue and fatigability increased significantly in HCE (Day $X2(4)=77.84$; $p<.001$; and $F(4,130)=11.58$; $p<0.001$). Rating of sleep quality worsened in HCE (Day $F(4,130)=26.48$; $p<.001$).

CONCLUSION
These results show that even specialized personnel trained for mountain warfare suffer from negative effects of HCE on cognitive performance, general fatigue and sleep perceived quality. There was no significant effect of HCE on cognitive performance pre-exercise. But, post-exercise, cognitive performance decreased significantly on the first day, indicating a degree of cognitive fatigue induced by operating in hypoxic, cold and a challenging environment. Moreover, military exercise was perceived as more mentally demanding and fatiguing in HCE compared to low altitude.

MILITARY IMPACT
This study provides insights on acute cognitive performance detriment of specialized soldiers when operating in extreme cold and hypoxic environments. Countermeasures for cognitive fatigue to sustain soldiers' performance, especially during the first day in HCE, are warranted.

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Thematic 23 : Performance at high altitude

#46785877
Poster Presentation

Seasonal Modulation of Short-Term Adaptations to Moderate Altitude: Comparative Physiological Responses to Arduous Winter and Summer Marine Corps Training

BACKGROUND
Arduous military training conducted in mountainous environments presents a unique model for examining the combined effects of hypobaric hypoxia (HH), physical exertion and seasonal climate extremes with associated caloric deficit, which may modify the acclimatization process. The purpose of this study was to compare short-term physiological adaptations to moderate-altitude exposure (~2,500 m) during Marine Corps Mountain Leader Courses conducted during the winter (WLC) and summer (SLC).

METHODS
Data from forty-three unacclimatized Marine Corps servicemembers (SLC: n=20 Age: 28±6y, Height: 179.4±7.7 cm, Mass: 81.9±9.8 kg; and WLC: n=23 (female=2), Age: 25±3y, Height: 177.3±8.4 cm, Mass: 83.6±9.4 kg) who completed either the SLC or WLC were used for analysis. Blood and body mass (kg) were assessed at three times during the course [Pre (wk-1), Mid (wk-4), and Post (wk-7)] and analyzed for differences in hemoglobin (Hb), hematocrit (Hct), hypoxia inducible factor 1 alpha (HIF-1α), erythropoietin (EPO), and aldosterone (ALD). Generalized linear mixed models were used to assess changes over time and between courses, a=0.05. All procedures were approved by the appropriate Institutional Review Boards.

RESULTS
We observed significant interactions between Pre and Mid, season and time for Hb (SLC Pre: 14.94±0.96; Mid: 15.89±1.51; vs. WLC Pre: 15.07±1.10; Mid: 14.39±1.51; (g•dL-1) (interaction p=0.001)), Hct (SLC Pre: 44.00±2.38; Mid: 46.83±4.53; vs. WLC Pre: 44.43±3.38; Mid: 42.62±4.46; (%); interaction p=0.012), and HIF-1α (SLC Pre: 1412.89±1675.00; Mid: 1009.33±863.60 vs. WLC Pre: 788.14±574.38; Mid: 832.50±581.93; (pg•mL-1); interaction p=0.017). Additionally, a main effect of time was observed for EPO with decreases from Pre to Mid and Pre to Post, (14.89±7.50; 12.83±5.22; 11.76±4.82 (mIU•mL-1); p=0.010, (p=0.002), respectively; and ALD (129.16±102.23; 68.51±71.28; 64.61±64.55 (pg•mL-1); p=0.002, <0.001, respectively). Lastly, a significant interaction (p=0.003) was observed for mass, being -1.6% lower in SLC (95% CI [.21 – 5.68], kg) vs -4.3% lower in WLC (p<0.001, CI [5.99 – 9.88], kg) following training.

CONCLUSION
EPO and HIF-1α were elevated at Pre (over sea level norms), followed by lower ALD from Pre to Mid, typical precursors for hemoconcentration and the effects on Hb and Hct in SLC, but absent in WLC. WLC had a greater loss in body mass, suggesting a larger caloric deficit. While both courses are physically demanding, cold-induced thermogenesis may play a role in the deficit. An energy deficit contributes to a disruption in the process for altitude adaptation that is necessary for hemoconcentration and Hb production.

MILITARY IMPACT
Findings may have implications for optimizing training, monitoring, and performance in military personnel operating in mountainous environments. For example, allowing additional time for acclimatization in cold weather operations, potentially reducing physiological stress and improving performance.

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Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388

Salle Lucienne et André Blin - R. Gilgen + T. Reilly

ORAL PRESENTATIONS

Implementation of MSKI prevention programs: comparison between an operational unit and military training courses

Basic Training Model for Musculoskeletal Injury Prevention

Early detection of attrition and injury risk in military training

French military physiotherapists from the French Defence Central Health Service : concrete implications during overseas operations

Changes in Physical Fitness and Physical Activity Behaviour From Recruitment to Basic Military Training as Predictors of Musculoskeletal Injuries in Swiss Recruits

Musculoskeletal Injury Trends and Physiotherapy Workload in Canadian Armed Forces Personnel on Operation REASSURANCE

POSTER PRESENTATIONS

Barriers and facilitators to MSKI prevention initiatives in the Canadian Armed Forces

Guidance on evidence based MSKI interventions in the military environment

Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388

#46497982
Oral Presentation

Implementation of MSKI prevention programs: comparison between an operational unit and military training courses

Preventing musculoskeletal injuries (MSKI) is a priority for militaries worldwide, and standardized, progressive physical training (PT) programs tailored to occupational, or training demands can reduce MSKI incidence. However, military training courses and operational units differ substantially in structure, tempo, and control over physical activity, influencing the feasibility and effectiveness of PT based MSKI prevention interventions.

Training courses typically involve members living on base, following fixed schedules, with limited involvement in sports, and completing instructor directed PT within time limited plans. In contrast, operational units have variable tempo, members often live off base, and individuals have greater autonomy over physical activity outside duty hours including sports and recreational pursuit. There is less influence by command on overall training load. NATO Research Task Group HFM 388 includes an implementation framework for PT based MSKI prevention. This work supports that effort by comparing feasibility, physical performance outcomes, and MSKI incidence associated with standardized PT programs implemented within Canadian Armed Forces (CAF) training courses and operational units. This project received approval from the Human Research Ethics Committee.

Across multiple studies in the Canadian Armed Forces we have demonstrated that standardized, progressive PT programs maintained or improved physical fitness while reducing MSKI incidence, dependent on intervention duration and occupational or training demands. Physical fitness was maintained (0±6%) during shorter, highly demanding training courses, while greater improvements were observed in operational units and lower demand courses (20±11%). MSKI incidence was reduced across all settings, including up to 58% fewer overuse injuries during basic infantry training and a 12% reduction in MSKI related healthcare visits per person year in an operational unit. Feasibility analyses indicated that implementation did not increase resource burden and did not compromise training or operational effectiveness.

Despite overall feasibility and effectiveness, contextual differences influenced implementation. Training courses allowed greater control over physical demands but were constrained by shorter duration and competing qualification requirements. Operational units supported longer interventions but exhibited substantial variability in individual physical demands, recovery opportunities, commitment to the intervention and access to PT facilities and equipment. Overall, standardized PT programs are feasible and effective in both military training courses and operational units. Maximizing impact requires deliberate consideration of environmental constraints, competing physical demands, and recovery opportunities unique to each setting.

AUTHORS

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Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388

#46501288
Oral Presentation

Basic Training Model for Musculoskeletal Injury Prevention

BACKGROUND
All military recruits engage in strenuous physical training which often leads to high musculoskeletal injury (MSKI) rates. Often, basic concepts of exercise physiology and sport training are overlooked due to the need to train large numbers of individuals and the difficulty of tailoring programs to individual needs. Nevertheless, research from both the United States (US) and Canada (CA) has demonstrated practical and scalable solutions within basic training programs that have resulted in meaningful reductions in MSKI. The purpose of this collaboration is to present 2 evidenced based interventions which have reduced MSKI incident in basic training environments resulting in meaningful improvements in operational readiness.

METHODS AND RESULTS
Two prospective observational efforts were conducted during basic military training in the US and CA to examine workload characteristics, caloric expenditure, training structure, and MSKI outcomes, as well as the effectiveness of injury prevention strategies. In the US recruits volunteered over a three year period (n = 2,705). Data were collected on workload, estimated caloric expenditure, exposure to load carriage and running events, and MSKI incidence. Recruits walked approximately 10–12 miles/day, with average caloric expenditure ranging from 3,000 to 4,900 kcal/day. Analysis revealed that load conditioning hikes and running events were the primary contributors to MSKI. Implementation of a progressive load conditioning program resulted in a 39% reduction in MSKI compared with control. In CA, recruits undergoing basic military training volunteered over three years (n = 4083). Measures included workload, time spent in moderate to vigorous physical activity, caloric expenditure, fitness status, and MSKI occurrence. Recruits accumulated between 212 and 272 minutes of moderate to vigorous physical activity per day, with estimated daily caloric expenditure ranging from 3,515 to 4,106 kcal. Lower fitness was associated with increased MSKI risk. A holistic training approach incorporating a fitness screening test, structured recovery sessions, and program modifications led to a 56.1% in time loss to injury when comparing fiscal year 2022–2023 to 2023–2024.

CONCLUSION
These data suggest that an initial step in MSKI prevention is quantifying total workload and identifying training events that disproportionately contribute to MSKI. This allows targeted program modifications, such as progressive load exposure and recovery integration, to support adaptation and minimize injury risk during large group training.

MILITARY IMPACT
Implementation of evidence-informed workload management strategies during basic military training can significantly reduce musculoskeletal injury risk, improving force readiness, training efficiency, and long-term soldier health without compromising physical performance standards.

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Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388

#46635117
Oral Presentation

Early detection of attrition and injury risk in military training

BACKGROUND
In times of increasing operational demands and challenges in recruitment and retention, maintaining a sufficient and resilient military workforce is of growing importance. Military training of high-performance individuals, such as non-commissioned officers, is physically and mentally demanding, with high dropout rates commonly driven by injury, illness, and stress-related withdrawal. To reduce attrition and injury risk, training programs should not only focus on physical fitness, but also assess recruits' wellbeing. This study aims to evaluate the impact of baseline screening and ongoing monitoring on attrition risk, using physical examinations, psychological questionnaires, and weekly wellness assessments throughout training. The findings may inform improved monitoring strategies to enhance recruit wellbeing, training efficiency, and force sustainability.

METHODS
168 male recruits underwent baseline physical and psychological evaluations at the start of Military Infantry training. Psychometrics were measured using the Connor-Davidson Resilience Scale, Stress Mindset Measure, Short Grit Scale, Motivation and Chronotype questionnaire. Physical fitness was tested with 400-m, 2400-m and 5-km runs, prone and side bridge, 2-minute push- and sit-up, CMJ, Y-balance, and wall squat. Secondly, on a cohort of 37 recruits, the Short Recovery and Stress Scale, motivation and pain rating scale were conducted weekly throughout 8 weeks of training.

RESULTS
During 8 weeks follow-up, 51 recruits withdrew (30.36%). Independent-samples t-tests were used to compare groups. Retreated recruits had significant lower baseline scores in Resilience ($p<.001$), Stress mindset ($p<.001$), Grit ($p=.009$), Amplitude ($p=.004$) and motivation ($p<.001$). No significant differences were found in baseline physical performance test results.

Weekly questionnaires revealed that recruits who later deviated from the training schedule (withdrawn of injured) reported significantly higher pain ($p=.015$) and stress ($p=.012$), alongside lower recovery and motivation scores ($p= .014$) in the weeks preceding injury or withdrawal.

CONCLUSION
Baseline psychological assessments, rather than physical performance were strongly associated with dropout risk. Moreover, longitudinal wellness monitoring identified early warning signs in recruits who later became injured or withdrew. Combining baseline screening with continuous in-training monitoring could provide a more sensitive approach for early risk detection during training.

MILITARY IMPACT
Integrating psychological screening and routine in-training monitoring may enable timely, targeted interventions for recruits at risk. This approach potentially reduces preventable injuries and attrition, optimize training, and support the development of a resilient and sustainable military force.

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Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388

#46706410
Oral Presentation

French military physiotherapists from the French Defence Central Health Service : concrete implications during overseas operations

BACKGROUND

The French Defence Central Health Service ("Service de Santé des Armées") is a French joint-army organization that includes 74 military physiotherapists, mainly working in national military hospitals. Due to their military status, they can be deployed on overseas operations. An initial training helps French physiotherapists develop military abilities during their first year of service. Then, a complementary training is provided before deployment to overseas missions. This latter training includes specific instruction such as combat rescue and primary care for psychological victims. This training pathway enables military physiotherapists to provide care for French soldiers deployed abroad. Military hospital physiotherapist teams can reorganize their activity to maintain quality care while enabling the deployment of a physiotherapist on overseas operations.

METHODS

No studies have analyzed the specific role of French military physiotherapists yet. This document is a synthesis based on data issued from the professional experience of French physiotherapists during overseas operations. During their missions, physiotherapists collect data related to the type of rehabilitation sessions they provide.

RESULTS

During overseas operations, French military physiotherapists are integrated into medical teams on airbases or on aircraft carriers. They have two main roles: the prevention and treatment of musculo-skeletal disorders, and the treatment of minor traumatic injuries in order to avoid medical repatriation of soldiers. Regarding injury prevention, military physiotherapists analyze recurrent health issues in the field and then develop specific programs to avoid them. When prevention is not enough, they intervene at the early stage of injury in order to optimize recovery and to allow a quick return to operational duties. French military physiotherapists provide care to Air Force crews (fighter and transport aircraft crews) to prevent and treat flight-related disorders such as neck pain or back pain.

They also provide care to Army soldiers, mainly for shoulder pain, back pain or tendinitis, and traumatic injuries such as sprains or strains. During rehabilitation, physiotherapists spend extended periods of time with patients. This prolonged contact allows them to work collaboratively with the medical team to identify early signs of post traumatic stress disorder in soldiers.

CONCLUSION

Integrated within deployed medical teams, French military physiotherapists are contributors to healthcare delivery during overseas operations. They support both the physical and the psychological health of soldiers. The diversity of populations treated, including aircrew and ground forces, highlights the adaptability of physiotherapy practice to operational constraints and mission-specific demands.

MILITARY IMPACT

French military physiotherapists help maintain soldiers' operational readiness and reduce the need for medical evacuation. Their observational role facilitates early identification of psychological distress. This synthesis opens perspectives for future studies aimed at evaluating the impact of military physiotherapy on operational performance, injury incidence, and long-term health outcomes in deployed forces.

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Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388

#46746833
Oral Presentation

Changes in Physical Fitness and Physical Activity Behaviour From Recruitment to Basic Military Training as Predictors of Musculoskeletal Injuries in Swiss Recruits

BACKGROUND
Basic military training (BMT) exposes recruits to sustained high physical loads, psychological stress, and limited recovery, resulting in a substantial risk of musculoskeletal injuries (MSKI). This study investigates changes in objectively assessed physical fitness and subjective reported general physical activity behaviour (PAB) from recruitment to the start of BMT and tests whether baseline levels and changes over time are associated with MSKI and dropout during BMT.

METHODS
513 male Swiss recruits (20±1 years, 178±7 cm, 73.7±11.1 kg) from communications intelligence, armored infantry, rescue technicians, and fusilier infantry performed physical fitness tests (PFT) and completed questionnaires assessing PAB at recruitment as well as at start of BMT. Acute and overuse MSKI during BMT were obtained from medical records and dropouts were recorded. Four multivariable binomial logistic regression models were fitted separately for acute MSKI, overuse MSKI, total MSKI, and dropout, including troop branch, smoking, pre-BMT MSKI, PFT and PAB at recruitment, and changes in PFT and PAB from recruitment to the start of BMT. Effects are reported as odds ratios (OR) with 95% confidence intervals (CI); p-values are based on Wald-tests. Model discrimination was quantified using the area under the ROC curve (AUC) with 95% CI.

RESULTS
A total of 166 (32.4%) recruits sustained MSKI during BMT, 49 acute and 130 overuse injuries were reported. Model discrimination ranged from moderate to good: acute MSKI AUC = 0.75 (95% CI 0.69–0.82), overuse MSKI AUC = 0.64 (0.58–0.69), total MSKI AUC = 0.68 (0.63–0.73), and dropout AUC = 0.68 (0.61–0.76). For total MSKI, higher risk was associated with troop branch (rescue technicians: OR 2.00, 95% CI 1.17–3.43, p=0.012; fusilier infantry: OR 6.53, 3.09–13.79, p<0.001), pre-BMT MSKI (OR 1.64, 1.08–2.50, p=0.021), and an increase in seated shot put (SSP) points from recruitment to BMT start (ΔSSP points: OR 1.10, 1.01–1.19, p=0.031). For acute MSKI, fusilier infantry (OR 6.37, 2.24–18.10, p<0.001), smoking (OR 2.15, 1.08–4.25, p=0.028), ΔSSP points (OR 1.18, 1.03–1.34, p=0.014), and higher PAB at recruitment (per category: OR 2.23, 1.12–4.47, p=0.023) were significant. For overuse MSKI, rescue technicians (OR 2.22, 1.25–3.93, p=0.007) and fusilier infantry (OR 3.54, 1.65–7.59, p=0.001) were significant. No significant predictors were observed for dropout (all p>0.05), pre-BMT MSKI (OR 1.85, 0.96–3.55, p=0.064) was borderline.

CONCLUSION
MSKI risk during BMT was primarily associated with troop branch, prior MSKI, and an increase in upper-body strength from recruitment to BMT start, whereas the other PFT components and PAB measures showed limited independent associations. Overall model discrimination was moderate for total and overuse MSKI and good for acute MSKI, supporting the potential for early risk stratification at BMT entry. Further research is warranted to clarify troop-specific factors contributing to these risk differences.

MILITARY IMPACT
In Switzerland, recruitment provides a critical window to assign conscripts to the appropriate troop branch. However, the strong association of injury risk with troop branch suggests that training content and load progression within the respective BMT unit are major drivers of MSKI. Military organisations should therefore combine pre-entry preparation recommendations with troop-specific training adaptations to reduce MSKI burden and limit attrition.

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Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388

#46764533
Oral Presentation

Musculoskeletal Injury Trends and Physiotherapy Workload in Canadian Armed Forces Personnel on Operation REASSURANCE

BACKGROUND
Musculoskeletal injuries (MSKI) are a leading health concern in military populations and significantly affect operational readiness. Surveillance of injury trends and their operational impacts enable targeted prevention strategies. Deployed physiotherapists provide timely MSKI management to reduce duty time lost and repatriations. On Operation REASSURANCE (Op REA) in Latvia, physiotherapy clinical statistics offer insight into workload and injury trends. This study quantifies physiotherapy workload and describes injury profiles to guide prevention efforts.

METHODS
A retrospective descriptive analysis of 2024–25 physiotherapy workload data for Canadian Armed Forces (CAF) personnel on Op REA included three categories of encounters: assessments, follow-ups, and sick-parade/drop-ins. Injuries were categorized by body region, mechanism, and acuity. Disease and Injury Surveillance System (DISS) data, compiled by the Directorate of Force Health Protection, complemented these findings.

RESULTS
In 2024–25, physiotherapy recorded 2,458 encounters, (528 assessments, 1,335 follow-ups, and 595 sick-parade/drop-ins). The most common injury sites were low back (17%), shoulder (16%), knee (15%), and ankle (15%). Physical training accounted for 37% of injuries, followed by work-related mechanisms at 31%. Acuity distribution included 33% Priority 1 (acute), 45% Priority 2 (subacute), and 23% Priority 3 (chronic). The DISS captured 4,744 MSKI-related clinic visits over the same period, representing approximately 25% of all deployed clinic visits. MSKI resulted in 13,228 duty days lost, roughly 60% of all lost days.

CONCLUSION
Physiotherapy workload on Op REA remained consistently high, driven primarily by low back, shoulder, knee, and ankle injuries associated with physical training. Most cases were acute or subacute, highlighting the importance of timely physiotherapy access to support readiness. The DISS data and duty-days losses further demonstrate the significant operational impact of MSKI. These trends underscore the need for targeted, evidence-informed prevention strategies. Enhanced classification of physical training exposures in 2026—distinguishing self-directed, unit-led, and PSP-led activities—will strengthen injury surveillance and prevention.

MILITARY IMPACT
Historical surveillance data demonstrate that physical training injuries are a major contributor to MSKI morbidity among deployed CAF personnel. Strengthening collaboration between physiotherapists and deployed fitness staff can support implementation of evidence-informed injury-prevention strategies. Improved categorization of physical training exposure in 2026 will further enhance prevention efforts and support operational readiness.

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Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388

#46496766
Poster Presentation

Barriers and facilitators to MSKI prevention initiatives in the Canadian Armed Forces

BACKGROUND

Musculoskeletal injuries (MSKIs) represent a substantial and persistent challenge for militaries worldwide, contributing to reduced operational readiness, career interruption, non-deployability, medical attrition, and increased healthcare costs. Although targeted, evidence-based interventions can reduce MSKI incidence, military environments present structural, cultural, and operational barriers that limit implementation and long-term sustainability. In support of the NATO HFM-388 Research Task Group on the Implementation of Evidence-Based Military Physical Training to Prevent Non-Battle Injuries, this study aimed to identify key barriers and facilitators influencing MSKI prevention initiatives within the Canadian Armed Forces (CAF).

METHODS

A 33-item questionnaire, adapted from Rhon et al. (2024) to reflect the CAF context, was administered across multiple training bases and operational units. Personnel from all elements, ranks, and force components were targeted, including non-commissioned members, non-commissioned officers, junior officers, and senior officers. The study received approval from the Human Research Ethics Committee.

RESULTS

Seventy-nine CAF members responded (mean age 36.7±8.6 years; 15.6±8.4 years of service; 7% female). Participants represented Army (96%), Air Force (2%) and Support Trades (2%), included both Regular (91%) and Reserve (9%) Force members, and spanned the full chain of command (12% non-commissioned members, 41% non-commissioned officers, 32% junior officers, 15% senior officers). Only 53% reported awareness of specific MSKI prevention programs within the CAF.

Perceived primary contributors to MSKI included existing or unresolved injury (68%), body composition (49%), low physical activity levels (46%), poor physical training planning or delivery (44%), and low muscular strength (43%). Responsibility for MSKI prevention was most commonly attributed to Military Leaders (38%) and Individual Service Members (31%), followed by PSP fitness staff (18%); only 1% identified Health Services staff, and 12% were unsure. The most frequently reported available resources were Personnel (42%) and Educational resources (41%), whereas the most prominent resource gaps were Time (71%), Personnel (66%), and Education (53%). Key barriers to implementation included Time Constraints and Scheduling Demands (66%), Personnel Shortages (25%), Competing Training Requirements (8%), and Lack of Education (5%).

CONCLUSION

This study identifies critical barriers and facilitators influencing the implementation of evidence-based MSKI prevention initiatives within the CAF. Consistent with NATO HFM-388 objectives, these findings provide actionable insights to support the effective, scalable, and sustainable implementation of MSKI prevention strategies across military training and operational contexts.

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Thematic 24 : Prevention of musculoskeletal injuries - OTAN HFM RTG 388

#46764690
Poster Presentation

Guidance on evidence based MSKI interventions in the military environment

BACKGROUND
Musculoskeletal injuries (MSKI) represent a persistent threat to military readiness, contributing to lost training time, reduced operational capability, and increased burden on health services. Despite extensive research identifying MSKI risk factors, the translation of this knowledge into effective prevention strategies within military physical training (PT) environments remains challenging. Traditional PT is often non-standardized, inconsistently progressed, and poorly aligned with the physical and physiological demands of training courses, operational units, and deployments. There is a critical need for structured, evidence-based guidance to support the design and implementation of PT programs that mitigate MSKI risk while maintaining operational readiness.

METHODS
This work synthesizes evidence from military and athletic training literature to develop a comprehensive outline for evidence-based PT program design in military environments considering: (1) review of MSKI epidemiology and injury mechanisms; (2) characterization of military training contexts across basic training, occupational training, operational units, and deployments; and (3) application of core training principles including standardization, progressive overload, specificity, and individualization. Central to the outline is a physical demands analysis combining document review, stakeholder consultation, and, where feasible, objective measurement of load, volume and intensity of physical activity and physiological strain. The outline further defines roles and responsibilities for stakeholders and processes for implementation, evaluation, and train-the-trainer models to support sustainment.

RESULTS
MSKI prevention is most effective when PT programs are purpose-driven, standardized, and explicitly aligned with occupational demands. Training courses with high physical demands and limited recovery capacity benefit from PT focused on MSKI risk reduction and maintenance of performance, whereas operational units and deployments allow greater opportunity for progressive fitness development. Research evidence consistently supports standardized, progressive PT programs over non-standardized or ad hoc approaches, showing improved MSKI outcomes and reduced duty limitations. Emphasis is on total workload quantification, identification of high-risk training events, and appropriate recovery as critical determinants of success.

CONCLUSION
Evidence-based PT in military settings requires more than identification of MSKI risk factors; it demands systematic integration of physical demands analysis, evidence-based training principles, stakeholder engagement, and continuous evaluation. Properly designed and implemented PT programs can reduce preventable MSKI without compromising training objectives, improving operational readiness.

MILITARY IMPACT
This work provides practical, adaptable guidance to inform PT policy, course design, and unit-level training across the military training continuum with the potential to reduce MSKI, preserve force readiness, optimize training efficiency, and improve long-term health and sustainability of military personnel.

AUTHORS

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Thematic 25 : Physiology in cold environments Part I

Salle Lucienne et André Blin - T. Ojanen + H. Teien

ORAL PRESENTATIONS

Comparison of Tactical Combat Casualty Care Skills in Arctic and Temperate Environments

To measure is to know, if you know what you measure: skin temperature under cold and windy conditions

The Effect of Exercise Intensity on the Wind Chill Temperature Index

Impact of Heated Gloves on Barehand Manual Dexterity in Extreme Cold (-40°C): A Preliminary Study

POSTER PRESENTATIONS

Acclimation to cold air environments for performance- more questions than answers

Potential of a heated garment to enhance extremity cold protection and reduce the bulk of military helicopter aircrew cold weather clothing

Enhanced Thermal Protection of an Improved Air Force Immersion Suit during Simulated 14°C Maritime Cold-Water Immersion

Field Testing Autonomous Heated Footwear for Frostbite Prevention in Extreme Cold Environments

Monitoring body skin temperatures and sleep quality by wearable technologies on Danish soldiers participating at a Winter Warfare Course in January 2026 in Northern Sweden

Torso Heating Improves Finger Blood Flow, Temperature and Fine Dexterity in the Cold.

Thematic 25 : Physiology in cold environments Part I

#46574582
Oral Presentation

Comparison of Tactical Combat Casualty Care Skills in Arctic and Temperate Environments

BACKGROUND
The Tactical Combat Casualty Care (TCCC) approach to battlefield medicine follows the MARCH acronym (Massive hemorrhage, Airway management, Respiratory/breathing, Circulation, Hypothermia prevention), which organizes treatment priority and highlights medical skills required to provide life-saving interventions. In cold weather, TCCC interventions must remain timely and effective to maintain high-quality care. Currently, there are limited data on how cold affects each specific skill of the MARCH protocol. This study compared TCCC skill completion times in cold temperatures.

METHODS
Twelve military medical providers (5 M, 7 F; mean±SD age: 31±8 years, height: 169±9 cm, weight: 78.8±15.2 kg) completed four randomized trials in an environmental chamber at 24, 1, -15, and -31 °C. Before each trial, medical supplies were cold soaked for 120 min in the respective temperature. Participants donned the Extended Cold Weather Clothing System Gen III (selecting layers to match the environment) and then cold soaked for 30 min in the respective temperature. Proctor-instructed skills were then completed following the MARCH protocol. The timing of each step of the skill was electronically recorded. Physiological data (core and skin temperature) were recorded throughout. Repeated measures ANOVAs compared outcomes across conditions, with significance set at $p < .05$.

RESULTS
Cold exposure significantly slowed 5 of 19 (26%) TCCC skills, impacting the Massive hemorrhage (M), Airway management (A), and Circulation (C) portions of the MARCH protocol. Specifically, the time to don gloves, insert a nasopharyngeal airway, and administer an IV was significantly longer in -31 °C compared with all other conditions ($p's < .05$), with delays from 22 to 44 s. Time to apply a pressure dressing and complete a patient assessment also increased in cold conditions ($p's < .04$). Finger and mean skin temperatures during TCCC skill completion were colder in -15 and -31 °C compared with warmer conditions ($p's < .001$). Core temperature did not differ between cold exposure trials ($p's > .12$).

CONCLUSION
Findings suggest that time to complete several TCCC skills increased in cold conditions, with delays up to 44 s. These delays are likely due to impaired manual dexterity and cold-induced equipment deterioration. To maintain high-quality cold weather medical care, it is necessary to identify solutions to maintain dexterity and develop cold-resistant medical equipment.

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Thematic 25 : Physiology in cold environments Part I

#46657335
Oral Presentation

To measure is to know, if you know what you measure: skin temperature under cold and windy conditions

BACKGROUND
Accurate skin temperature measurement is essential for assessing thermal strain in cold environments. This study evaluated the accuracy of four contact sensors (iButtons, BodyCAP, MSR, ADInstruments) under cold and windy conditions and examined the effect of insulation on measurement accuracy.

METHODS
A water-bath test (5-40°C) was used to determine the systematic bias compared to a high precision reference thermometer and to calibrate all four sensors. Subsequently, 19 participants completed two climate chamber trials: in windy chill (-7°C, 2.5 m/s wind) and cold chill (-15°C, 0.2 m/s wind) conditions. Each sensor type was tested bare and insulated on the forearm. Infrared thermography (IRT) served as reference temperature. Within sensor comparisons between climatic conditions and between bare – insulated were done using Wilcoxon signed-rank tests for mean bias and Cramér-von Mises tests for distribution shape. Proportional bias between each skin temperature sensor type and IRT was evaluated using Bland-Altman analysis.

RESULTS
The water-bath comparison showed that all sensors performed within acceptable accuracy ranges, with biases from −0.13 to 0.29 °C. In human trials, insulation consistently led to an overestimation of temperatures relative to IRT (median bias range bare sensors: -1.24-2.84 °C, insulated sensors: 1.41-7.5 °C, $P < 0.04$ for all sensors in both windy- and cold chill). iButtons exhibited overestimation bias in cold chill and underestimation bias in windy-chill conditions, while BodyCAP, MSR, and ADInstruments were unaffected by condition. Median bias was predominantly positive (i.e., systematic overestimation). Bland-Altman analysis showed that all sensors demonstrated temperature-dependent bias in the windy-chill condition, with larger deviations relative to IRT at higher temperatures. Error distribution shapes were not significantly different between conditions or between bare – insulated.

CONCLUSION
Skin temperature sensors showed acceptable accuracy in the controlled water bath condition, but exhibited systematic biases relative to IRT during human trials. Insulation consistently led to an overestimation of skin temperatures, and iButtons were sensitive to wind, while other sensors were unaffected by wind. Bias also increased at higher skin temperatures in the windy condition for all four sensor types.

MILITARY IMPACT
By enhancing the choice of skin temperature sensors, this study supports more reliable assessments of human thermal physiology in cold and windy environments. These improvements help prevent erroneous conclusions and allow for more confident conclusions in future research regarding military performance in extreme environments.

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Thematic 25 : Physiology in cold environments Part I

#46699025
Oral Presentation

The Effect of Exercise Intensity on the Wind Chill Temperature Index

BACKGROUND
Military cold weather operations carry significant risk of cold injuries. The Windchill Temperature Index (WCTI) is used as a general risk indicator, but ignores key (military) factors including exercise intensity and peripheral thermal responses. This study aims to improve operational relevance of the WCTI by incorporating these factors.

METHODS
Eleven participants completed three 60-min cold chamber sessions (–10°C, 1.85 m/s wind), each with a different exercise intensity (LOW: standing; MED: walking at 4.8 km/h; HIGH: walking at 4.8 km/h with 5% incline), using a randomized within-subject design. Skin temperature and heat flux were measured at the cheek, finger, and toe. Statistical comparisons were performed using pairwise tests with Holm correction.

RESULTS
During the final 10 minutes of cold exposure, cheek temperature was higher in the HIGH exercise intensity condition (14.8 ± 2.1°C, P = 0.012) than in LOW and MED (12.2 ± 1.9°C; 12.7 ± 1.2°C), while cheek heat flux did not differ between sites (LOW: -336.8 ± 64.8 Wm-2, MED: -380.5 ± 135.4 Wm-2, HIGH: -373.5 ± 130.6 Wm-2, P = 0.530). Conversely, finger and toe temperature was higher with exercise intensity (finger LOW: 8.53 ± 1.7°C, MED: 22.9 ± 9.2°C, and HIGH: 31.5 ± 1.7°C, P = 0.003; toe LOW: 12.8 ± 2.0°C, MED: 25.5 ± 7.5°C, and HIGH: 31.4 ± 4.8°C, P = 0.003), whereas heat flux showed the opposite (finger LOW: -60.3 ± 25.1 Wm-2, MED: -114.0 ± 65.0°C, HIGH: -140.0 ± 28.6 Wm-2, P = 0.001; toe LOW: -93.2 ± 16.1 Wm-2, MED: -139.1 ± 38.4°C, HIGH: -173.5 ± 36.6 Wm-2, P < 0.001).

CONCLUSION
Exercise intensity altered thermal responses in the extremities, whereas cheek responses were minimally affected. Incorporating activity-dependent extremity data into the WCTI may therefore improve cold injury risk estimation.

MILITARY IMPACT
These results show that the Windchill Temperature Index may inaccurately estimate cold injury risk. Incorporating activity-dependent peripheral responses into guidelines could improve clothing choices and operational risk decisions in cold environments.

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Thematic 25 : Physiology in cold environments Part I

#46802400
Oral Presentation

Impact of Heated Gloves on Barehand Manual Dexterity in Extreme Cold (-40°C): A Preliminary Study

BACKGROUND
In extreme cold, individuals may briefly remove insulated mittens and liner gloves to perform tasks that require manual dexterity. However, this practice greatly increases the risk of frostbite. This project assessed whether field-ready electrically heated gloves could maintain hand/finger temperatures, offset manual dexterity declines, and reduce frostbite risk during exposure to extreme cold.

METHODS
Nine military personnel completed this study. Participants sat passively in extreme cold (-40°C air) for 40 min prior to performing manual dexterity tests. Participants wore heated liner gloves (Quanta Vici, CAN) for each trial, with the heat either turned off (CON) or on the highest heat setting (HG) under issued mittens. Prior to manual dexterity tests, participants removed both their mittens and liner gloves. Manual dexterity was assessed using the Purdue Peg Board where participants placed pegs into peg holes with their dominant (PP1) or non-dominant hand (PP2). Following the test, participants donned their mittens and rewarmed for 3 min. Dominant distal finger temperature (5th digit), PP score (#), and PP tolerance time (s, stopped if finger skin temperature reached 0°C) were measured. Paired samples t-test were used to compared differences between trials. This study was approved by our institutional human research ethics board (HREC2019-042).

RESULTS
The HG led to a significantly higher ($p=0.008$) dominant finger temperature at 40 min prior to PP1 (27.7±7.2°C) compared to CON (10.2±1.8°C). Total trial tolerance time was also greater in HG (65.3±7.93 min) than in CON (47.1±4.4 min; $p=0.039$). For PP1, participants in the HG condition demonstrated significantly longer tolerance times (24.0±6.0 s vs. 9.0±4.0 s; $p<0.001$) and higher performance scores (10.0±3.0 pegs vs. 4.0±2.0 pegs; $p<0.001$) compared with CON. Similarly, for PP2, there were greater tolerance times ($p=0.004$) and scores ($p<0.036$) in HG (20.0±6.0s, 7.0±2.0 pegs) compared to CON (10.0±2.0s, 4.0±1.0 pegs).

CONCLUSION
Overall, HGs led to higher finger temperatures (albeit still reduced below baseline) during 40 min of passive rest in extreme cold prior to bare hand exposure. The higher skin temperature delayed the time before bare fingers reached a critical risk temperature of 0°C and improved dexterity scores compared to no heating. However, the effectiveness of HG diminished with repeated bare hand exposure. Therefore, although HG provide some benefits, careful task analysis should be used prior to implementation by military personnel

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Thematic 25 : Physiology in cold environments Part I

#46600340
Poster Presentation

Acclimation to cold air environments for performance- more questions than answers

BACKGROUND
The number of personnel working in areas of extreme cold is increasing. The melting of sea ice in polar regions is opening transport links and creating new sites for international competition and contention. As a result, human performance in cold environments is becoming increasingly important. Unlike heat acclimation, there are no commonly used strategies for acclimation or habituation to the cold.

METHODS
Several reviews have been conducted which outline the evidence concerning cold acclimation/habituation, focusing on different populations and mechanisms. As such, the present work did not seek to replicate these, but instead, summarise the research findings and practices for cold air adaptation, and identify current gaps and/or limitations of existing work for military relevance.

RESULTS
Several studies have attempted habituation or metabolic acclimation using a variety of protocols including both cold air and cold-water immersion. As science has progressed and interest in reducing acclimation time has increased, the duration of cold habituation/acclimation protocols has reduced. However, study designs often feature participants wearing minimal clothing which, for occupational roles, is not ecologically valid. Many of the protocols utilise ambient temperatures (8-12°C) that are not representative of the extreme cold conditions of Arctic regions. Finally, many of the acute cold air protocols have failed to show any physiological, subjective or performance improvements, thereby raising the question of whether the exposure was sufficient to induce adaptations. The question therefore remains, does cold acclimation/acclimatisation/habituation provide a thermogenic response to the cold that is sufficient to deliver a meaningful thermoregulatory or performance benefit to humans that are adequately dressed in the cold? Are habituation protocols more beneficial for behavioural practices (i.e. becoming comfortable in the uncomfortable) or psychological resilience?

Finally, the impact of multiple stressors (e.g. sleep deprivation, chronic energy deficit) or other interventions (recent heat acclimation) on the effectiveness of cold habituation/acclimation is unclear. This presentation will discuss the evidence and apparent gaps, encouraging a healthy debate.

CONCLUSION
The utility of cold acclimation strategies in mitigating decrements to operational performance has yet to be determined. Questions remain about: i) the efficacy of cold habituation/acclimation when individuals are wearing cold weather clothing; ii) the impact of other stressors, or interventions, on the effectiveness of acclimation; and iii) the time-course of adaptation.

MILITARY IMPACT
Armed Forces personnel must remain ready to operate at high levels of performance in extremely cold environments. Determining whether cold acclimation/habituation achieves readiness will establish whether this is an avenue which Defence should invest further research.

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Thematic 25 : Physiology in cold environments Part I

#46721482
Poster Presentation

Potential of a heated garment to enhance extremity cold protection and reduce the bulk of military helicopter aircrew cold weather clothing

BACKGROUND
Military aircrew must wear several clothing and equipment layers (termed AEA) to mitigate thermal and non-thermal hazards. Protecting the hands from cold is a particular issue for helicopter aircrew. The potential of a heated garment (HG) to warm the extremities and reduce AEA bulk was investigated in an aircrew relevant laboratory study.

METHODS
12 participants (4 women) undertook a 75-min test in a laboratory (Air temperature, TA, -10 °C) wearing a commercial, two-piece HG (with centrally located heat pads, 50 W) and components of a helicopter cold weather AEA on two occasions (HG: OFF or ON). After a baseline period (TA, 20 °C), the cold test comprised 15 min periods of alternating standing while undertaking dexterity tasks (0-15 & 30-45 min) and bench stepping (15-30 & 45-60 min) with aircrew gloves worn, and a final dexterity period with gloves removed (60-75 min). Heart rate (HR), rectal temperature (TRE), finger and back skin temperature (TSK F and TSK-B) and thermal sensation/comfort and gloved/bare-hand fine / gross dexterity measurements informed HG performance. The statistical analysis used Generalised Linear Mixed Models with heating and time effects considered using a Likelihood Ratio Test. Differences at specific time points were identified by pairwise comparisons with a Bonferroni correction. Statistical significance was taken at $p<0.05$. Model-derived means are provided with 95th percentile confidence values [lower, upper].

RESULTS
HR and TRE increased and decreased in line with the physical activity profile but were not influenced by heating. Heating increased TSK-F ($p<0.001$) but differences were confined to end of the dexterity periods at 45 min (OFF, 20.9 [17.1, 24.6] °C; ON, 27.5 [23.7, 31.2] °C; $p<0.05$) and 75 min (OFF, 12.0 [8.2, 15.8] °C; ON, 18.5 [14.8, 22.3] °C; $p<0.05$). Heating reduced finger cold sensation ($p<0.01$) but had no impact on finger thermal comfort. Heating increased TSK B ($p<0.001$) at all time points ($p<0.001$) with a mean value of 36.2 °C (OFF) and 39.9 °C (ON). Heating increased back heat sensation ($p<0.001$) and heat discomfort ($p<0.001$) which was most pronounced during exercise ('Hot' and 'Uncomfortable' ratings). Heating had no impact on dexterity performance.

CONCLUSION
A heated garment has the potential to warm the fingers of aircrew operating in cold environments, and reduce the overall insulation requirement of AEA, which could reduce clothing bulk and glove thickness. It is likely that body heating would be best suited to more sedentary aircrew roles, and during periods of more intense physical activity, the user would need the ability to reduce the intensity or turn the heating off. Further studies could optimise the intensity and location of heating and exploit advances in battery efficiency and e-textiles.

MILITARY IMPACT
With potential for future conflicts in extreme cold and the increase in clothing and equipment worn by warfighters, strategies to mitigate the risks of cold and increased burden on military personnel are needed. This study provides proof-of-concept support for the use of such a mitigation strategy with potential application in the air and land domains.

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Thematic 25 : Physiology in cold environments Part I

#46747987
Poster Presentation

Enhanced Thermal Protection of an Improved Air Force Immersion Suit during Simulated 14°C Maritime Cold-Water Immersion

BACKGROUND
Cold water immersion accelerates peripheral heat loss due to the high thermal conductivity of water, increasing the risk of hypothermia during maritime emergency scenarios. Aircrew performing overwater missions depend on immersion suits to preserve thermal balance until rescue. However, limited human-based evidence exists comparing thermophysiological responses between standard and improved immersion suit systems under realistic cold-water exposure. This study evaluated whether an improved Air Force immersion suit enhances thermal protection and perceptual tolerance during simulated maritime 14°C cold water immersion.

METHODS
Eleven healthy adult males (23.5 ± 3.6 y) completed a randomized crossover study wearing a Standard or Improved immersion suit. After 10 min of seated rest, subjects underwent 40 min of supine immersion in 14°C water. Rectal temperature, gastrointestinal temperature, mean skin temperature, regional skin temperature, metabolic rate, and subjective shivering onset were recorded continuously. Repeated measures analysis of variance and linear mixed models were applied. Statistical significance was set at $P < 0.05$.

RESULTS
Core temperature did not differ significantly between suits. However, mean skin temperature demonstrated a significant condition × time interaction ($F = 40.045$, $P < 0.001$). The cooling rate was greater in the Standard suit (-0.156°C/min) compared to the Improved suit (-0.094°C/min). During 31–40 min of immersion, mean skin temperature was significantly higher in the Improved condition ($P < 0.05$). Water penetration was significantly reduced in the Improved suit (89.8 g vs 307.1 g, $P = 0.018$). Shivering onset occurred slightly earlier in the Improved condition ($P = 0.050$), but peak shivering frequency was delayed compared with the Standard suit.

CONCLUSION
Although core temperature stability was maintained in both conditions, the improved immersion suit significantly attenuated peripheral cooling and reduced internal water ingress during prolonged 14 °C immersion. Enhanced insulation performance became evident under cumulative cold stress.

MILITARY IMPACT
Improved peripheral thermal protection and reduced water penetration may prolong functional survivability following maritime ejection or overwater operations. These findings support evidence-based refinement of Air Force immersion suit systems to enhance operational readiness and resilience in high-intensity maritime environments.

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Thematic 25 : Physiology in cold environments Part I

#46763455
Poster Presentation

Field Testing Autonomous Heated Footwear for Frostbite Prevention in Extreme Cold Environments

BACKROUND
Extreme cold presents significant challenges to warfighters, posing risks such as frostbite and compromised operational effectiveness. A major limitation of current peripheral heating technologies is that no foot temperature feedback is integrated into the heating system. Excessive heat can increase sweat production, especially during strenuous activity, and may increase risk for cold weather injury. The purpose of this project was to evaluate heated boot liners with a foot temperature feedback system to autonomously provide peripheral heat in extreme cold. Materials and

METHODS
During cold weather military training in the Canadian Arctic, heated liners were evaluated in outdoor temperatures ranging from -12 to -40 °C. Independent wireless temperature sensors were affixed to each liner near the toe area and liner temperatures were logged each minute. Each outdoor test included control liners (i.e., liners not supplied with power; n = 7) and liners in autonomous heating mode (n = 10). Liners were placed in Arctic-rated boots with the boot top occluded to capture internal boot temperature where the foot would be when worn. Each test lasted for up to 6 hours, and group comparisons were made between liners with and without battery power. Significance level was set at $p < .05$.

RESULTS
Across all tests, a total of 2,324 minutes (39 hours) and 3,320 minutes (55 hours) of temperature readings were obtained for control and autonomous heated liners, respectively. Temperature comparisons indicate that the autonomous heated boot liners provided tightly controlled heat output during all testing while maintaining an internal boot temperature of 25.1 ± 0.3 °C, whereas the control boot liners (no heat) resulted in an internal boot temperature of -8.8 ± 10.7 °C; $p < .001$. Additional outcomes suggest similar autonomous heating performance following an 18-hour cold soak (-29 °C) of the heated boot liner batteries and documented battery life of 13 hours when worn by human subjects.

CONCLUSION
The low variability in internal boot temperature suggests repeatable and sustained autonomous heating performance, making this technology a likely viable option for cold weather injury mitigation. Human subject testing in cold weather military training events is in progress and will provide further insight into the efficacy of this technology, which may be useful for other occupational, recreational, and civilian populations exposed to cold.

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Thematic 25 : Physiology in cold environments Part I

#46763784
Poster Presentation

Monitoring body skin temperatures and sleep quality by wearable technologies on Danish soldiers participating at a Winter Warfare Course in January 2026 in Northern Sweden

BACKGROUND
The ability to recover physically is essential for continuous battle readiness in cold environments. Physical recovery is dependent on the quality of sleep, which in turn is affected by the cold. Hence, this study investigated the impact of the cold on body skin temperatures (S.TEMP) and sleep quality (S.QUA) during a Winter Warfare Course (WWC) and tested the durability of the wearable technologies used in the study (e.g., battery lifetime, data storage capacity, and the sturdiness of the patches attaching sensors to the skin).

METHODS
Sixteen soldiers (28±3 yrs., 186±7 cm, and 92±13 kg) volunteered for the study, which complied with national regulations. Data were collected during a 6-day military training exercise in the Lomben range (sub-arctic terrain). The soldiers remained outdoors 24/7 and slept in non-heated tents. Temperatures ranged from -26°C to 0°C with an average of -12°C and wind speeds ranging 1-3 m/s. Physical activity data were collected using SENSMOTION (sensor on thigh). Total sleep time were analyzed based on activity data collected between 21:00 and 07:00 and S.QUA were defined using a weighted sleep score calculated as: ((Sleep no movements x 1) + (sleep movements x 0.5) + (sleep active x 0))/total sleep time. Scoring >0.70 = good quality; 0.70-0.50 = intermediate quality; <0.50 = poor quality. Body S.TEMP were measured using STEADYTEMP patches placed in the armpit (core), on the foot and the back of the hand (extremities = average of foot and hand temperatures)). A questionnaire (Karolinska sleepiness score) provided subjective measures of S.QUA and the Magazine Loading Test (MLT; number of bullets loaded in magazines in 130 s wearing gloves), tested the impact of cold exposure on manual dexterity.

RESULTS
Average S.TEMP (n=15) measured for core were 33.8±1.7°C (spread 8.1°C) and for extremities 30.7±4.4°C (spread 19.3°C). Average S.TEMP during daytime for core were 33.4°C and for extremities 29.9°C and during nighttime for core 34.7°C and for extremities 32.7°C.

The soldiers slept (n=15) on average 8.48±0.84 hrs. with an average sleep weighted score of 0.9±0.0. Karolinska sleepiness score (n=16), scored on average 5.4±1.9 on a scale from zero to 35 (the lower the score the better S.QUA). The MLT showed a significant decrease of 22% (n=16) when performed in a cold environment compared to indoor environment. The wearable technologies functioned satisfying; battery life and data storage capacity were sufficient throughout the study period. However, the STEADYTEMP patches were more exposed to wear and tear, particularly the patch worn on the hand. Of the total 45 patches used (n = 15), nine patches worn on the hand had to be replaced during the study, in addition to four foot patches and one armpit patch.

CONCLUSION
Despite S.TEMPs of the extremities reaching very low levels (~15°C), as reflected by reduced performance in the MLT, the soldiers were able to rewarm and achieve good S.QUA, supported by higher average S.TEMPs measured at night compared to daytime and subjective measures of S.QUA. Monitoring S.QUA and S.TEMP using wearable technologies is both possible and feasible in cold environments.

MILITARY IMPACT
Poor sleep negatively affects physical battle readiness and cold hands impair manual dexterity and therefore soldiers' ability to handle military equipment (e.g., weapons). Real-time monitoring may provide opportunities for immediate adjustments during training, thereby enhancing feedback quality and learning outcomes during WWCs.

AUTHORS

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Thematic 25 : Physiology in cold environments Part I

#46766346
Poster Presentation

Torso Heating Improves Finger Blood Flow, Temperature and Fine Dexterity in the Cold.

Cold weather operations require insulated clothing, but gloves impair dexterity. Warming areas other than the fingers has been shown to improve peripheral blood flow, indirectly warming the fingers and enhancing fine motor control in the cold. This pilot study investigated whether lower power levels - approximately half that used in previous studies - could still be effective for battery-powered heating elements. The research tested a novel approach that combined a smaller heating surface area with the periodic modulation of heating power and the use of a heat-conductive fabric to distribute warmth.

Eight volunteers (5 male) underwent two test conditions which varied in whether torso heating was applied or not but were otherwise identical. Each test comprised a 10-minute period of baseline (rest @ 28°C), 10 minutes of light exercise (to eliminate central vasoconstrictor drive), 12 minutes of 35°C dry water immersion (to clamp finger temperature) and 60 minutes of stationary exposure to cold air (5°C). A proprietary heating system was used to warm the torso, which included ten individually controlled heat pads. These pads, each 12x7cm, were housed in Dyneema™ fabric pockets with thin (3 mm) polystyrene insulation placed over the top and were distributed across the front and back of the torso. The heating cycle was modulated between two different power levels delivering around 40 watts of heat. Participants (who were barehanded) wore the heating pads (in both conditions) along with multiple layers of clothing to provide approximately 1.6 clo of insulation. Finger temperatures, cutaneous blood flow (Laser Doppler Flowmetry; LDF), and finger pulse amplitude (photoplethysmography; PPG) were continuously measured. Core (rectal) and skin temperatures (underneath heat pads, on chest, forearm and toe), blood pressure, thermal sensation (hand, whole body) pinch strength and fine dexterity (Purdue Pegboard test) were periodically assessed. Data were analysed using a two-way repeated measures ANOVA (or non-parametric equivalent where relevant).

The heat pads increased skin temperature underneath them by 6.5°C (5.7-7.2°C) by the end of the cold exposure when compared to without heating. Torso heating significantly improved finger skin temperature and blood flow in the cold. Without torso heating dexterity was impaired during cold exposure, with statistically significant differences ($p < 0.05$) from baseline observed in the final two Purdue tests which were associated with mean finger temperatures below 13°C. In the heated condition, no such effect on dexterity was observed and performance in the last three Purdue tests were significantly better ($p < 0.05$) in the heated compared to unheated conditions. Furthermore, hand thermal comfort at the end of cold exposure improved significantly ($p < 0.01$), shifting from a median of -3.5 (cold/very cold) without heating to -1.5 (slightly cool/cool) with heating. Interestingly, torso heating also raised toe temperature, which was about 5.4°C (3.2-7.5°C) higher at the end of the cold exposure compared to the unheated condition.

Torso heating at 40 watts reduces peripheral vasoconstriction, which better maintains finger temperature in the cold and improves dexterity.

Further studies combining torso heating with ultra-thin gloves (to address conduction losses) are warranted to enhance performance on tasks requiring fine motor skills in cold environments.

AUTHORS

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Testimonies from Ukrainian soldiers and round table about physical performance challenges for Ukrainian front soldiers

Thursday 18th June, 15:15 to 16:15

Four years of high-intensity warfare under conditions of sustained national defence have revealed the physical and psychological burdens placed on frontline soldiers of the Armed Forces of Ukraine (AFU) to an extent not yet systematically captured. The following observations constitute the evidence base justifying the creation of a holistic physical performance programme.

Andreii Babin

He’s an International Cooperation Officer of Department of Health, at the Ministry of Defense of Ukraine.
He is graduated from University as international economics specialist in 2001. And at the same time, he’s engaged as lieutenant in reserve.
His peaceful life was related to my career in HVB, ING and SEB Banks’ subsidiaries in Ukraine. Later, he ran his own business.
In 2022, he was mobilised to protect homeland as a platoon commander. As of today, he initiates a pilot project to propose solutions to the decrease in the endurance of combat unit personnel and maintaining the effectiveness of their tasks. He manages the building of an international working group, including Germany, Great Britain and Netherlands parteners and dedicated to "Enhancing Physical Endurance of Combat Personnelein Armed Forces of Ukraine".

Yuliia Zmievska

She currently serves as the Chief Specialist of the Medical Care and Medical Evacuation Division within the Health Department of the Ministry of Defense of Ukraine.
She holds degrees in medicine, law, and management, as well as a Ph.D. in medicine.
Her work is focused on the rehabilitation of military personnel and the reintegration of those released from captivity.
Until 2025, she worked in the field of forensic medical examination and served as a freelance consultant for a public health center.

Part 1_Ukrainian feedback : Challenges in Physical Performance during the Russian Full-Scale Invasion of Ukraine (Andrii Babin,UKR)

The first difficulty consists in insufficient physical parameters of the available personnel, their physical exhaustion in the conditions of prolonged hostilities. The context of large-scale operations have reminded a forgotten challenge relying on shortage of physically trained mobilization resource.The type of combat has emphasized an old matter of the load carriage burden of the soldier with the heavy weight of ammunition.

In the fourth year of full-scale war, non-battle losses – including musculoskeletal injuries (MSKI), cardiovascular events and the effects of chronic stress – have become almost comparable in scale to direct combat losses. Physical readiness has therefore shifted from a matter of fitness norms to a strategic issue of human capital preservation.

A significant share of recruits is older than 40–45 years, frequently presenting with obesity and cardiovascular disease. Existing norms and methodologies were not designed for this cohort – a uniform “one-size-fits-all” approach produces injuries as early as basic training.

Prolonged rotations in trenches and dugouts (up to several months) without adequate recovery, sleep, or regeneration; carrying heavy equipment and sustained exposure to extreme weather conditions. The AFU’s current physical training programme is built on Soviet-era doctrine and does not reflect these operational realities.

There are no validated field-based fitness tests linked to real combat tasks (Physical Employment Standards) and no scalable train-the-trainer instructor system exists. The absence of a systematic measurement and management framework prevents evidence-based development and quality assurance.

This statement recognized the need to develop recommendations for updating the legal and regulatory documents governing physical training. The objective is not to copy foreign models blindly, but to proceed on the basis of evidence.

Another driver of rethinking physical training programme is ensuring interoperability with NATO standards, contributing to their joint refinement and helping to build a shared security infrastructure across the region and continent. NATO partner experience demonstrates that a holistic approach reduces injury and illness rates and that investment in physical performance programmes yields a return on investment in the order of 1:8. This is a decisive argument for strategic management decisions concerning human capital.

This leads to the creation of a working group with NATO countries that are interested in solving the problem and invest their resources for the development of a pilot program driven by evidence of the need, designed with scientific-evidence and assessed in identified testing units to obtain practical results (primarily increasing combat capability and maintaining it in long term).

Part 2_Developing a Holistic Physical Performance Programme for Front Soldiers (Andreas Wolschendorf, GER)

The deficits identified above are systemic in nature and cannot be resolved through isolated, ad hoc measures. Project P3 therefore develops and tests an integrated, evidence-based programme structured around three pillars – **physical performance, nutrition and psychological/cognitive resilience** – with a defined pilot phase, structured data collection and evidence-based verification of effectiveness prior to scaling.

Work Stream 1: Physical Training and Rehabilitation
Development and testing of differentiated training programmes for three phases of military activity:
- General military basic training (Basic Recruit Training / BRT)
- Operations in restricted conditions (Frontline Deployment)
- Core emphasis is based on Strength & Conditioning (S&C), load carriage capacity and phase-specific regeneration strategies – from pre-deployment preparation through frontline service to post-deployment recovery and return to duty.

Work Stream 2: Nutrition
Development and testing of functional nutrition approaches for service members, including the preparation of a basis for further NATO standardisation recommendations on general military nutrition, complementary to existing standards on combat rations (STANAG 2937, STANAG 2556).

Work Stream 3: Psychological and Cognitive Resilience
Implementation of methodologies for psychological recovery support, assessment of cognitive performance and measures to enhance stress resilience among personnel.

Work Stream 4: Digital Component and Data Analysis
Use of wearable devices and digital platforms for the collection of physiological indicators, forming the data basis for training load management and programme evaluation.

Work Stream 5: Instructor Training (Train-the-Trainer)
Establishment of a scalable system for qualifying non-commissioned officers and junior officers of the pilot units as physical training instructors, including in-person training events. This ensures the programme can be independently sustained and extended within the AFU.

Military Impact
This programme has the potential to meaningfully shape the design of military physical training across NATO nations. Modern high-intensity combat demands a renewed emphasis on field-specific physical and psychological qualities – a finding of relevance far beyond Ukraine.

CLOSURE

INDEX

A:
Witzki Alexander
Sharifah Badriyah Alhadad
Wee Hon Ang
Melchior ARNAL

B:
Sebastian Baglole
Bradley Baker
Josh Bakker-Dyos
Beth Beidleman
Gregorio Bevilacqua
Aruni Bhatnagar
Kevin Bigelman
Rachel Blacklock
Thomas Bonne
Leonore BOURGEON
Tom Brandt
Henry Brewster
Juliette Bruin
Sylvain Bruni
Jenny Burbage
Matt Burgess
Brenda Bustillos

C:
Michelle Canham-Chervak
Marina Carboni
Robyn Cassidy
Sarah Chabal
Shaun Chapman
Ashley Charlebois
Ethan Chaumeret
Evan Chinoy
Yonghyun Cho
Charlotte Coombs
Nadine Cooper
Katelyn Culley

D:
Pronaya Prosun Das
Arnaud DAVIRE
MARCIO ANTONIO DE BARROS SENA
Sarah de la Motte
Herman de Vries
Thomas Derouck
Alain Dössegger
Tim Doyle
Ulrich Werner Josef Dr. Rohde

E:
Sophie Evans

F:
Pierre Fabries
Joanne Fallowfield
Zulfan Farhi
Lilian FAUTRELLE
Eva Fellinger
Marie-Helene FERRER
Peter Finch
Ben Fisher
Stephanie Fondi
Jennifer Forse

G:
Minke Geerts
Gabrielle Giersch
Kyle Gordon
Jenna Goulart
Tamara Grant
Julie Greeves
Alexandria Gregory
Tyson Grier
Mathias Guillard
Jessica Gwin

H:
Rasha Hammamieh
Joonas Helén
Joseph Hogan
Koen Hogenelst
Thomas Hölzl
Tuomas Honkanen
Merel Hoskens
Emily Howard

I:
Matthew Inscore

J:
Ralf Jaekel
Maria Jansson
Doug Jones

K:
Joona Kekkonen
Lisa Klous
Kristen Koltun
Andrew Kubala
Kristina Küper
Thue Kvorning

L:
Alice LaGoy
Marie-Andrée Laroche
Minhee Lee
HOJOON LEE
Nathaniel Lee
JooYoung Lee
CYRIL LINARD
Lotte Linssen
Mita Lovalekar
Klaus Luotola

M:
José Mauricio Magraner
Luana Main
Jan Maleček
Samuele Maria Marcora
Tessa Maroni
Runer Marson
Brian Martin
Mark Metcalfe
Alexandre Mir-Orefice
Eric Mol
Rachel Moore
Hamidou Msaidie
Patrick Mullie
Timothy Murray
Jussi Mussalo

N:
Jonpaul Nevin
Phil Newman
Dan Nicolella

O:
Regina Oeschger
Tommi Ojanen
Vladan Oláh
Thomas O'Leary
Josh Osofa

P:
Emily Paines
Heikki Peltonen
Matthew Perkins
Olivia Perry
Dk Nurul Zawanah Pg Hj Omar
Joseph Pierce
Kai Pihlainen
Théo PINALIE
Martin Poirier
Maaike Polspoel
Steven Powell
Rosemarie Prabhakaran
Dominic Pulford

R:
Caroline Rakowitz
Katrina Rawcliffe
Alex Rawcliffe
Bobby Rawls
Allen Redinger
Jaques Reifman
Tara Reilly
Jikke Reinten
Alexandria Remus
Julie Renberg
Aline Renz
Elliott Richardson
G Rietjens
Hedaya Rizeq
Caroline Rob
Andrew Roberts
Erin Robertson
Meg Robinson
Pete Roma
Paulien Roos
Lily Rosenblum
Daniel Rowland
Jose Rubio
Brent Ruby

S:
Pim Scheiberlich
Jennifer Schlie
Annette Schmidt
Jacqueline Scott
Pinata Sessoms
Elias Siebold
Alexander Sievert
Amy Silder
Anne Silverman
Clara Sjöblom
Doménica Solano Ocampo
Maher Souabni
Sara Spinabelli
Rich Stevenson
Michael Stone
Leonard Stratmann
MANOJ SUBEDI

T:
Hilde Kristin Teien
Frank Thøgersen
Andrzej Tomczak
Pavlos Topalidis
Julianne TOURON

U:
Angela Uphill

V:
Jani P Vaara
Jeroen Van Cutsem
Leanne Van der Hout
Suze Van der Mars
Koen Van der Sanden
Hugo Van Duijnhoven
Damien VAN TIGGELEN
Trevor Viboch
Mike Vignos

W:
Phillip Wallace
Shelley Walls
Tore Wangensteen-Haugen
Madeleine Warmer
Joseph Wasser
Andrew Weller
Jessica Wenghofer
Zach West
Jon Wheat
Christina Wiejak
Olivia Winther
Erik Witvrouw