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Contents

Key abbreviations and terminology

BBsq: Barbell-back squat

Repetition-Volume: Total repetitions performed within the exercise (BBsq) in the session.

VBT: Velocity-based Training

VLT: Velociy-Loss Threshold

30% VLT: Training performed until 30% velocity-Loss Threshold

20% VLT: Training performed until 20% velocity-Loss Threshold

Readiness: Pre-and in-session measures to determine individual`s degree of readiness to train, measured with following stipulations: "the difference between observed performance and expected performance" (Greig et al., 2020, p. 1878)

1RM: One-repetition maximum

Intensities: Percentage of the 1RM, i.e. 80% of 1RM = intensity of 80%

On-ice: Training or matches happening on the ice for Ice hockey athletes

TE: Typical Error

CMJ: Counter-movement Jump

SJ: Squat jump

RSI: Reactive Strength index

IMTP: Isometric mid-thigh pull

JH: Jump height

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Exploring the Relationship Between Readiness and Autoregulation in Barbell Back Squats Performed with Velocity Loss-Thresholds: An In-Season Intervention Study with Elite Junior Ice Hockey Players

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Forord:

Gjennom det siste året har jeg fått gleden av å arbeide med enormt engasjerte unge ishockeyspillere i en flott praktisk setting. Denne praksisen var givende og gøyal, til tross for de lange dagene meg og min medstudent Henrik V. Paulsen hadde på treningsfeltet. Jeg vil gjerne takke alle deltakerne og fysisk trener i klubben for et flott samarbeid og et flott prosjekt. Jeg vil også takke min medstudent Henrik V. Paulsen for et godt sosialt og profesjonelt samarbeid, samt Alphatek teamet og mine veiledere Håvard Myklebust og Thomas Bjørnsen.

Sammendrag:

Norwegian Version:

Hensikt: Undersøke graden av autoregulering som oppstår, og til hvilken grad readiness kan predikere volum i hastighetsstyrt knebøy, samt hvilke readinessmål fungerer best ved hastighetsfall-terskler.

Metode: Subjektiv readiness, svikthopp, knebøyhopp, reaktiv styrke indeks, isometrisk knebøy, gjennomsnittlige propulsive hastighet og flere knebøyserier ble innsamlet fra unge eliteutøvere i ishockey under en 15-ukers periode. Perioden inkluderte forskjellige styrketreningsøkter som benyttet to forskjellige hastighetstaps-terskler. Data fra 38 spillere ble analysert gjennom beskrivende statistikk, «dataflagging» der prestasjon avvikte ≥ 1 og ≥ 1.65 typiske feil fra individets flytende gjennomsnitt, korrelasjonsmatriser og multiple regresjons analyse.

Resultater: Baseline en-repetisjon maksimum i knebøy var 128.7kg ± 20.7kg. Typiske feilen ved readiness var mellom 3.1% (knebøyhopp) til 19% (subjektiv readiness), mens volum under hastighetstap-tersklene varierte mellom 10.4% og 14.9%, hvor 20% hastighetstap hadde lavere variasjoner. Variasjoner i subjektiv readiness, svikthopp og gjennomsnittlig propulsive hastighet viste signifikante korrelasjoner med volum (r = .251/.228/.203, p < .01, n = 158) under 30% hastighetstap tersklene. Bare gjennomsnittlig fremdrivende hastighet viste signifikant korrelasjon med volum (r = .157, p <.05, n = 213) under 20% hastighetstap tersklene.

Konklusjon: Autoregulering oppstår oftere i samme retning som endringer i readiness når hastighetstaps-terskelen på 30% benyttes, men tilfeldig når 20% hatighetstap terskel benyttes. Det beste batteriet for readiness i hastighetsstyrt knebøy inkluderer et subjektivt mål, et objektivt mål av løftehastighet og ved anledning noen svikthopp.

Nøkkelord:

Hastighetsstyrt styrketrening – Prestasjonsflagging – Subjektiv readiness – Svikthopp – Gjennomsnittlig fremdrivende hastighet

Abstract:

Objective: Examine the degree of autoregulation occurring, and to what extend readiness predicts repetition-volume in Velocity-based squats and what measures do so the best, during velocity loss-thresholds.

Methods: Subjective readiness, counter-movement jump, Squat Jump, Reactive strength index, isometric mid-thigh pull, mean propulsive velocity and multiple barbell back squats were collected from young elite ice hockey players during a 15-week period including strength-sessions with two different velocity loss thresholds. Data from 38 players were analyzed using descriptive statistics, "flagging" when deviating ≥ 1 and ≥ 1.65 typical error from players' individual moving-means, correlations, and multiple regression analyses.

Results: Baseline one-repetition maximum in the barbell back squat was 128.7kg ± 20.7kg. Typical errors for readiness ranged from 3.1% (Squat Jump) to 19% (subjective readiness), while repetition-volume during velocity loss were between 10.4% and 14.9%, favoring the lower velocity loss-threshold. Variations in subjective readiness, Counter movement jump and Mean Propulsive Velocity showed a significant small correlation with repetition-volume (r = .251/.228/.203, p < .01, n = 158) in 30% velocity loss threshold sessions. Only Mean Propulsive velocity had significant correlation with repetition-volume during 20% Velocity loss thresholds (r = .157, p <.05, n = 213).

Conclusion: Autoregulation happens more often in the same direction as changes in readiness when utilizing 30% Velocity loss-threshold, but randomly during 20% Velocity loss-thresholds. The best readiness battery for velocity-based barbell back squat includes a subjective measure, an objective measure of lifting speed, and if possible, some counter movement jumps.

Key words:

Velocity based training - Performance flagging - Subjective readiness - Countermovement jump – Mean propulsive velocity

1.0: Introduction

The sport of ice hockey can be recognized by the large demands from anaerobic as well as aerobic energy systems (Vigh-Larsen & Mohr, 2022). This is similar in many team sports, but particularly in ice hockey because of the large amounts of short bursts with anaerobic demands (Vigh-Larsen & Mohr, 2022). General fitness (maximal and enduring strength, power and VO^2-max) on its own, does not seem to be good a predictor of match performance for players in the Norwegian national upper league (Haugen et al., 2020). However, on-ice sprint speed specifically is deemed one of the most influential physical factors for performance in ice hockey (Laakso & Secomb, 2023). Even though general fitness could not differentiate the best from the mean, ice hockey athletes are generally very fit (Haugen et al., 2020). This ties together with the norm of three to five strength and conditioning sessions a week that National Hockey League athletes adhered to during off-, and pre-season (Ebben et al., 2004). Specifically, a Barbell back squat (BBsq) of two times bodyweight has been deemed something to strive for young elite athletes between 16-19 years old (Keiner et al., 2013). For young ice hockey players, resistance training could be especially important for injury prevention and strain toleration (Emery, 2003; Keiner et al., 2013; Meeusen et al., 2013). During the in-season period especially, the risk of overtraining and overreaching is at its highest (Meeusen et al., 2013). This places the importance of the balance between training and recovery (Meeusen et al., 2013). For that reason, it is normal to lower off-ice training, and strive to maintain or slightly improve strength and power abilities (Ebben et al., 2004).

Unfortunately, there is yet to be found a single marker that can identify the early overtraining-specter, which thereafter could be used to regulate training for optimal fatigue management (Meeusen et al., 2013). To better understand when to adapt training to match the athlete's daily performance the term "readiness" has been adopted. Readiness is in the literature interpreted in diverse ways, leading to ambiguity (Greig et al., 2020). In this article, readiness adopts the following definition "the difference between observed performance and expected performance" (Greig et al., 2020, p. 1878). In this aspect, readiness needs some normative data to compare observed performance with the expected performance (Greig et al., 2020). In practical sense, readiness can be measured through pre,- and in-session testing to determine changes in the scheduled training (K. Lindberg et al., 2022) and perhaps even identify early signs of overreaching through long-term performance monitoring (Meeusen et al., 2013).

Readiness seems to have different aspects that can be measured in both objective and subjective ways (Saw et al., 2015). A great tool in objective readiness assessment are force platforms, as they can be used to monitor maximal force without very taxing one-repetition maximum (1RM) tests, as well as explosive power through jump-tests (Merrigan et al., 2020). This aligns with the suggestion of K. Lindberg et al (2022), to use tests of power and maximal strength, with one caveat that the measurements are reliable. The Counter movement jump (CMJ) performed on a force platform have previously been found to be reliable both in the short and long term (K. Lindberg et al., 2022). However, it is important to not change training based on "unworthy" changes from the baseline (Greig et al., 2020). What should be deemed as to big of an anomaly from the norm has not yet been determined. The use of Typical Error (TE) and suggestions of smallest worthwhile change could probably be used (K. A. Lindberg et al., 2022; Turner, 2022).

The use of autoregulating training methods have been hypothesized to be valuable for athletes that engage in large training volumes (Byrkjedal et al., 2023). Autoregulating refers to the change of training based on the individual's performance or their expectation to perform (Greig et al., 2020; Larsen et al., 2021). This ties together with a meaningful change in readiness leads to an automated regulation in training. A particular autoregulating training regimen that has grown in interest the last 15 years is Velocity based training (VBT). VBT utilizes measurements of lifting speed to either determine volume or desired adaptation (Hirsch & Frost, 2019). There are two main methods: the use of velocity targets or Velocity loss thresholds (VLT) (i.e. percantage reduction in speed compared to the fastest lift during the set). Velocity targets utilizes a bandwidth of lifting speeds for the concentric phases for the lifts, and load is determined thereafter (Dorrell et al., 2020).

Current literature indicates that VLT of 10-20% elicit the best maximal and explosive strength developments in the lower extremities, while limiting fatigue (Pareja-Blanco, Rodríguez-Rosell, et al., 2017; Pareja-Blanco, Sánchez-Medina, et al., 2017; Rojas Jaramillo et al., 2024; Weakley et al., 2024; Włodarczyk et al., 2021). Smith machine squats performed with VLT of 20% exceeded 40%, and 15% VLT exceeded 30% in terms of changes in CMJ height performance ($p < .05$). The lower VLT also indicated larger 1 RM changes, however not significantly (Pareja-Blanco, Rodríguez-Rosell, et al., 2017; Pareja-Blanco, Sánchez-Medina, et al., 2017). In young novice soccer players, smith machine squats performed to 10% and 30%VLT with moderate intensities (i.e. 45-60% of 1RM) both elicited good improvements ($p < .05 - .0001$), however 10% VLT was slightly superior in all measured aspects with significantly ($p < .001$) less volume (Rojas Jaramillo et al., 2024). Cross sectional gains are the only parameter that higher (≥30%) VLT seemed to exceed lower (≤ 20%) thresholds (Włodarczyk et al., 2021). A lot of current literature utilizes the smith machine squat while the lessor stability in free-weight BBsq could impact velocities and subsequent adaptations (van den Tillaar & Larsen, 2020). Top coaches report large differences in day to day fluctuations in athletes ability to perform using traditional 1RM percentage based methods, and see VBT as a possible way of regulating training (Thompson et al., 2023).

Subjects in this study were young elite level ice hockey players in-season, participating in a VBT intervention with baseline and presession fatigue assessments through a readiness battery. The purpose was to examine the degree of autoregulation occurring during BBsq performed to 20% and 30% VLT, in-season for young ice hockey players. Secondly, to examine the extend readiness predicted repetition-volume (total repetitions performed), during the two VLT. Thirdly, to determine the best readiness test battery when applying VLT.

2.0: Methods

2.1: Design

A 15-week longitudinal experimental design was used, starting in the latter phase of the pre-season, and ending right before the December holiday. This study was part of a bigger project including a Randomized Controlled Trial on the use of two types of feedback on BBsq performance. The research protocol included three sub-periods: a 3-week baseline and pre-testing phase, followed by a 10-week intervention period, and a 2-week post-testing phase.

2.2: Subjects

In total, 38 semi-professional ice hockey players were recruited to participate. They played in the Norwegian national "under 20s (n = 23)" and "under 18s (n = 15)" ice hockey leagues. Recruited players were aged between 16- and 19 years old. Prior to their participation, all players provided written informed consent, demonstrating a voluntary commitment to the study`s objectives. Ethical clearance for the study was obtained from the Institutional Review Board of the Faculty of Health and Sports Science at the University of Agder (Appendix 1), and the study adhered to the ethical principles outlined in the Declaration of Helsinki. Furthermore, the study was reviewed and approved by the Norwegian Centre for Research Data (SIKT; Appendix 2) to ensure compliance with data protection and ethical standards.

2.3: Procedures and instruments

Baseline readiness as well as 1RM BBsq was assesed during the pre-season, in the three weeks preceding commencement of the intervention. All sessions were conducted with the same equipment and in the same gym during the baseline-and intervention period. Participants first engaged in a general warm-up consisting of 5 – 10 minutes on a stationary bike or similar low-intensity cardio. Then, in groups of 2 to 4 individuals, participants reported their 0-10 perceived recovery with guidance through a Norwegian translated reference (Laurent et al., 2011). Afterwards the participants underwent assessments on one out of two 85.2cm x 54.5cm force platforms (AlphaPWR, Alphatek, Stavanger, Norway). In the allocated groups the participants then performed Counter movement jumps (CMJ) in rotating order. The jumps were executed from self-selected depth, with a maximal explosive upward jump, with hands on their hips and landed with approximately extended knees, maintaining an angle of around 180° (Petrigna et al., 2019). Each participant performed three CMJs in total, and this rotating order protocol was then repeated for three Squat Jumps (SJ), Repeated jump test (10/5 RSI), and Isometric Mid-Thigh Pull (IMTP).

SJ involved a semi–squat position with knees bent at approximately 90◦ degree. Participants were required to maintain the bottom position for a minimum of two seconds before explosively jumping upward and landing with a knee angle of around 180° (Petrigna et al., 2019).

The repeated jump test employed the 10/5 Reactive strength index (RSI) method by Harper et al (2011) to assess the participants ability to jump as high as possible with minimal ground contact time (GCT). The 10/5 RSI test considers the mean values from the best 5 RSI-scores from a sequence of 11 consecutive jumps (Harper et al., 2011a). RSI is calculated by dividing jump height (JH) by GCT ($RSI = JH_m/CGT_s$).

In the IMTP assessment, participants began with warm-up pulls at ~50% of their maximum capability, followed by efforts at ~80-90% capacity, with brief rest periods lasting 5 to 15 seconds. They subsequently pulled with full effort, getting immediate peak force feedback. After pulling for a few seconds, they would terminate the exercise, and the highest measured peak force was documented. Handheld handles of standardized length (68.5cm) were attached to the floor next to the platform and hands were chalked up to mitigate grip limitations. The first baseline session was deemed a familiarization phase, due too exceptionally low scores. Between each try in every exercise, participants had rest periods of 30 - 90 seconds. The test battery was consistently executed in this prescribed sequence, with occasional deviations for the IMTP assessments.

2.3.1: Intervention period

During the intervention period the same readiness test battery was employed prior to leg training but with somewhat reduced volume. Specifically, the CMJ and SJ assessments were limited to two attempts per session and, due to logistical constraints, assessments of IMTP were conducted in only 10 out of 19 sessions.

The intervention started the first week of the in-season period. Participants engaged in structured resistance training, wherein they completed three sets of BBsq. Before starting the first set each participant did two-to-four specific warm-up sets, gradually increasing weight. A velocity-based training (VBT) regiment was utilized, with different velocity-loss thresholds (VLT) to determine the end of every set. VBT usually utilize measurements of bar speed as a form of immediate feedback (Weakley et al., 2021). In this study lifting speed was determined from ground-contact force, reflecting the system's (subject + barbell) center-of-mass movements. Velocity loss was calculated as deviation from the repetition with the fastest concentric mean propulsive velocity (MPV) and lifting progressed until the predetermined VLT. The Tuesday sessions utilized three sets with VLT of 30% with 80% of initial 1RM and was considered the hard session. The subsequent session was performed on Fridays with three sets with VLT of 20% with 70% of 1RM. This session was considered "easy" as it was 1-2 days prior to matches. Rest periods between sets were two to four minutes. In the sixth and eighth week of the intervention, the participants working weights were increased by a total of 2.5 and 5.0 kilograms.

During BBsq the participants were instructed to move explosively upwards in the concentric portion of the lift, and not to cheat on depth. During the first three repetitions the researchers verbally encouraged the participants, while the restoring repetitions the researchers gave technical feedback (e.g keep the depth). Intervention and baseline exercises were done at similar times of the day and implemented as the first part of the daily leg training. A few days some of the subjects adhered to on-ice training earlier the same day.

2.4: Statistical analysis

Statistical analyses were performed using IBM SPSS statistics version 28 (IBM Corporation, Armonk, NY, USA) and Microsoft Excel version 2311 (Microsoft, Redmond, WA, USA). All 38 recruited players were included in one or more analysis. To calculate test-retest reliability of the readiness measures, the last two baseline sessions were included, assuming players to be accustomed to the tests. To determine the within-subject coefficient of variation (CVw) the individuals SD were divided with their respective means. The average of all subjects' CVw were used as typical error (TE).

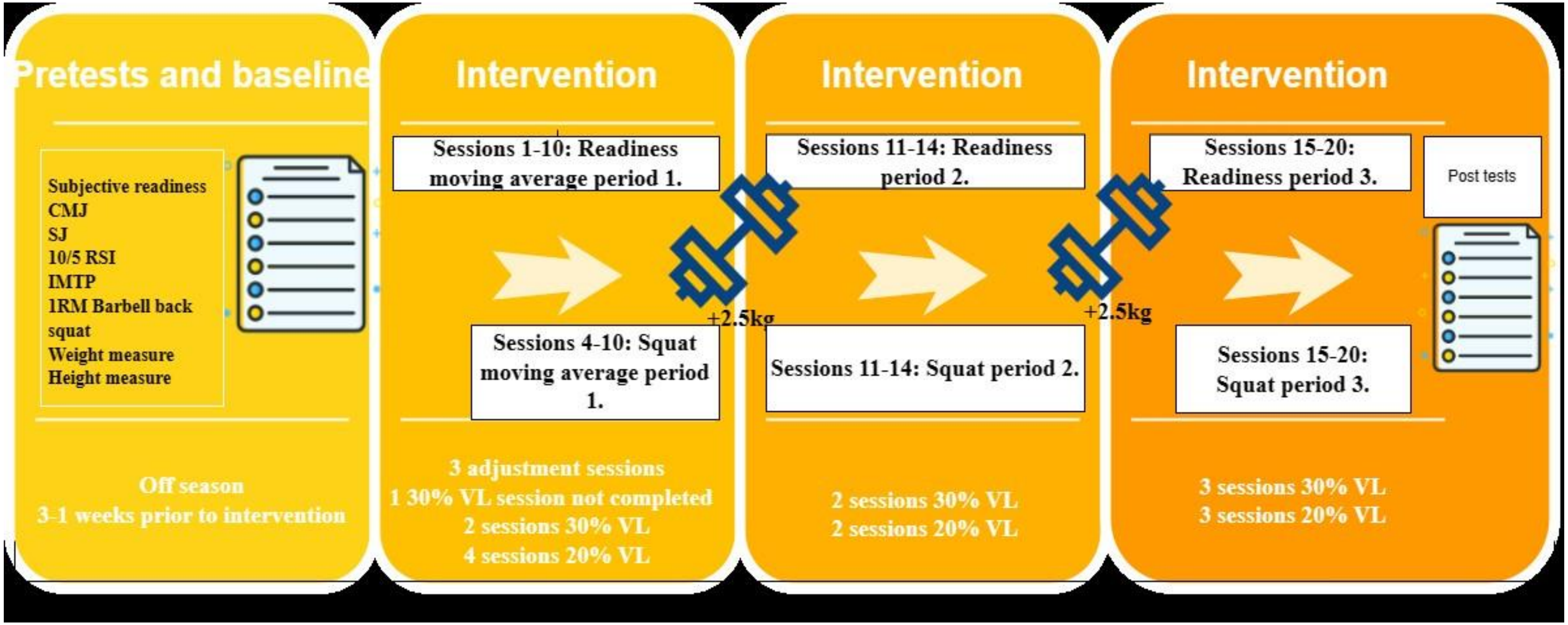
Squat data during the first three sessions were excluded from analysis due to customization to VBT. Further, there were six different loadings (70% and 80% of 1RM +2.5kg and +5kg) and individuals' means and CVs were determined in all these blocks for BBsq ("moving average"). To control for some fitness and technique gains, the moving average was determined in three periods for both readiness and squat (VLT of 30% and 20%): Period one: Sessions before additional loads, period two: sessions with 2.5kg added, and period three: sessions with 5kg added. See Figure 1 for an overview of the periods. Changes from the norm (moving average) were used for flagging, correlation matrix, and multiple regression. Participants with less than two squat sessions within a given period were excluded from CVw, correlation, flagging and multiple regression analysis for that time.

To identify theoretical anomalies outside the ~68% and ~90% percentile (according to the normal distribution curve), performance differing from the individual's norm by more than 1- or 1.65-times TE were flagged (Turner, 2022). Afterwards, these flags were paired in five categories. **Same sided =** Both repetitions and variable were flagged >1 Z-score; **Neutral =** neither repetitions nor variable were flagged; **±1=** Either repetition or variable were flagged between 1-1.65 Z-score; **±1.65** = Either repetitions or variable were flagged > ±1.65 Z-score; **Opposite =** Both repetition and variable exceeded ±1 Z-score, but in opposite directions.

Hierarchical multiple regression analysis was performed including the strongest correlating variables first, to determine the most effective readiness battery on predicting repetition-volume. Afterwards standard multiple regression analysis was performed to examine the whole battery. Due to few sessions including IMTP the test was excluded from multiple regression analysis.

Figure 1:

Overview of the Different Periods of Readiness and Squat for the Moving Average.



3.0: Results

The 38 Participants ranged from 16-19 years old with an average age of 17.2 ± 1.0 years, height of 181.1cm ± 6.2cm and weight of 77.4kg ± 8.1kg. Average baseline 1RM in BBsq was 128.7kg ± 20.7kg (n = 36). The participants executed on average 15.7 (3.3) repetitions during 30% VLT and 17.1 (3.5) for 20% VLT. The average repetition-volume decreased with additional weights (Table 1). The number of repetitions ranged from 6-31 and 8-31 for 30% and 20% VLT, respectively. However, the mean range was 12.8-19.1 for 30% VLT and 13.9-20.8 for 20% VLT. Variations in repetitions and MPV from session to session were larger in 30% VLT than 20% VLT. Squat period two, with 30% VLT deemed the largest test-retest reliability of 14.9%. For the readiness test battery, test-retest reliability ranged from 3.1% to 19%, with smallest variations for SJ and CMJ, and largest variations for subjective readiness (Table 2).

Table 1:

Test-Retest Reliability and Mean Values for Repetitions and MPV Performed Throughout the Periods

Squat periods →	**1. No additional load**	**2. +2.5kg**	**3. +5kg**
		30% VLT with 80% 1RM	
Mean repetitions ± SD (n=32)	17.3 ± 3.9	15.3 ± 3.9	14.8 ± 3.8
Repetitions TE	14.5% (n = 24)	14.9% (n = 23)	14.6% (n = 29)
MPV ± SD (n=32)	.46m/s ± .09	.43m/s ± .09	.43m/s ± .09
MPV TE	5.2% (n = 24)	4.8% (n = 23)	5.1% (n = 29)
		20% VLT with 70% 1RM	
Mean repetitions ± SD (n=32)	17.9 ± 3.7	16.8 ± 4.7	17.2 ± 3.7
Repetitions TE	11.2% (n = 35)	12.7% (n = 16)	10.4% (n = 30)
MPV ± SD (n=32)	.54m/s ± .11	.53m/s ± .10	.52m/s ± .11
MPV TE	4.5% (n = 35)	2.7% (n = 16)	4.0% (n = 30)

Note: **Squat periods** = Periods 1, 2 and 3 with weight increases for both 20% and 30% Velocity loss-threshold; **Mean repetitions** = Mean repetition-volume performed after three sets; **MPV;** Mean Propulsive velocity calculated from the highest MPV of each of the three sets in the session; **SD** = Standard deviation; **TE =** Typical error calculated as mean within-subject coefficient of variance from session to session in the given period; **n =** Subjects included in analysis.

Table 2:

Test-Retest Reliability of Measures in the Readiness Battery.

	Subjective	CMJ	SJ	5/10 RSI	IMTP
Mean	5.8	41.1cm	40.0cm	1.77m/s	254N
SD	1.43	4.85cm	4.64cm	.28m/s	38.6N
TE%	19%	3.2%	3.1%	5.1%	6.2%
Flag limits	± 1.1/1.8	± 1.3cm/2.2cm	± 1.2cm/2.1cm	± 9cm/14.9cm	± 16N/26N
n	32	32	32	32	30

Note. **Subjective =** Subjective perception of readiness; **CMJ** = Counter movement jump; **SJ** = Squat Jump; **RSI** = Reactive strength Index; **IMTP** = Isometric Mid-thigh pull; **SD** = Standard deviation; **TE** = typical error calculated as mean within-subject coefficient of variance; **Flag limits** = average change for flagged performance 1x/1.65x TE; **n** = Participants included in analysis

3.1: Flagging

During the 30% VLT sessions, repetition-volume was flagged 35 times (22%), with seven (4.4%) exceeding the 1.65 Z-score threshold. In three of those seven cases, CMJ also exceeded the same 1.65 Z-score threshold. During the 20% VLT sessions, repetition-volume was flagged 51 times (24%), with 19 cases (8.9%) exceeding 1.65 Z-score. Among the 19 cases only MPV exceeded the same 1.65 Z-score threshold, but only once. The readiness measures were generally flagged more often than repetition-volume (Table 3).

Table 3:

Relative Number (%) of Sessions Flagged for Readiness Measures and Squats (Repetition-Volume).

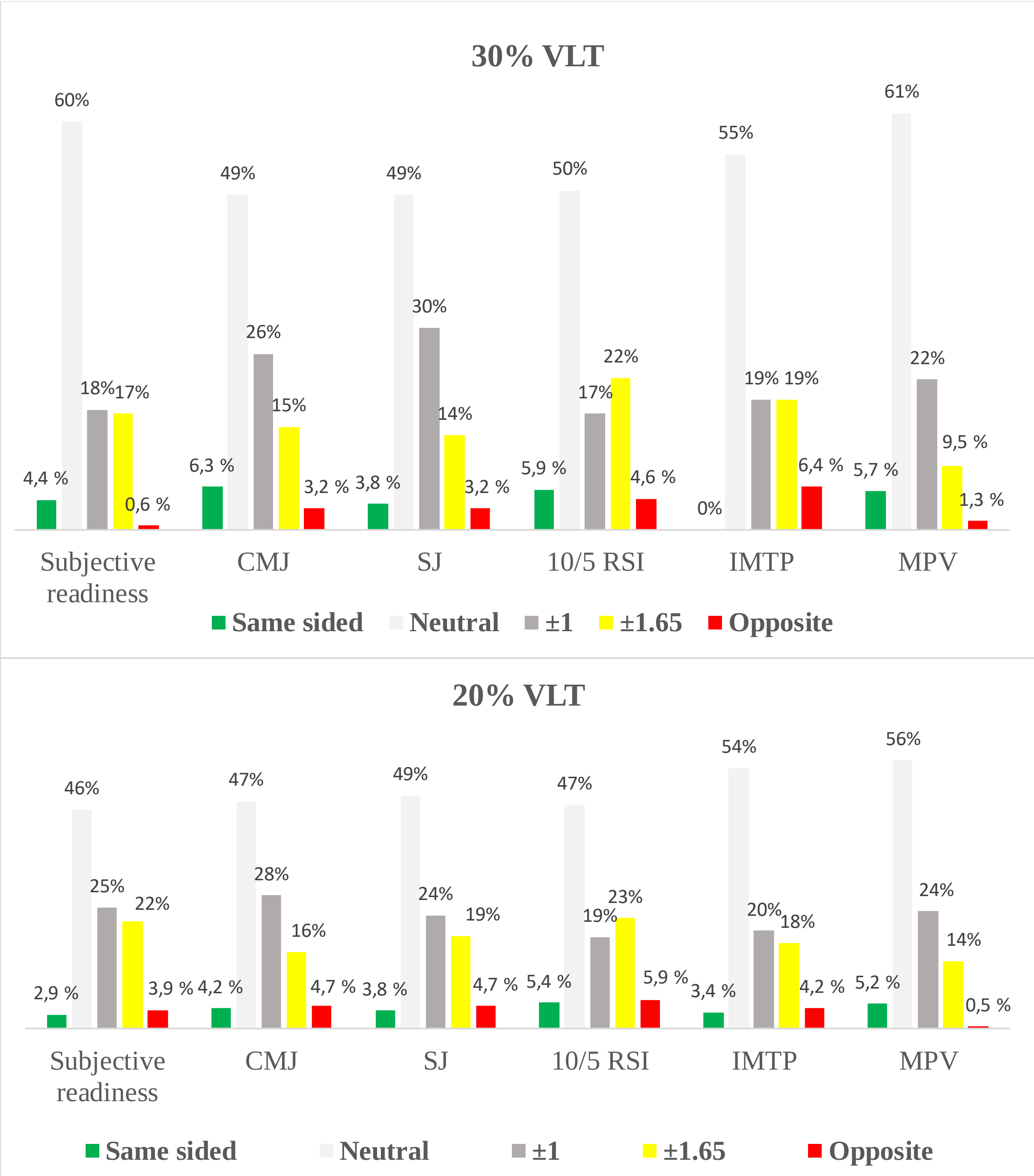
Measures	1 ≤ Z-score < 1.65		Z-score ≥ 1.65		Cumulative	
	20% VLT	**30% VLT**	**20% VLT**	**30% VLT**	**20% VLT**	**30% VLT**
Subjective readiness	18.4	8.9	19.4	12.7	37.9	21.5
CMJ	24.4	19.6	12.7	17.7	37.1	37.3
SJ	18.4	23.4	18.4	12.0	36.8	35.4
10/5 RSI	17.2	11.8	19.1	26.3	36.3	38.2
IMTP	16.9	12.8	12.7	17.0	29.7	29.8
MPV	17.8	13.3	8.0	10.1	25.8	23.4
Repetitions	15.0	17.7	8.9	4.4	23.9	22.2

Note. **1 ≤ Z-score < 1.65** = Data flagged above the threshold of ±1Z-score however not exceeding ±1.65 Z-score; **Z-score ≥ 1.65** = Data flagged at 1.65 Z-score or higher; **Cumulative** = The combined amount of flagged data exceeding ±1Z-score.

Across both VLT, MPV had the least number of opposite flags in relation to repetition-volume (3 cases, 0.8%). During a substantial portion of sessions, repetition-volume could not be predicted by one readiness measure alone (columns three and four in Figure 2). This means that in many sessions, either repetition-volume or the readiness measures would "flag" without predicted practical application. During 30% VLT, Subjective readiness showed the fewest opposite flags (one case). During 30% VLT sessions all measures had more same sided flags than opposite flags, except IMTP. During 20% VLT, MPV was the only measure that had more same sided flags than opposite flags.

Figure 2:

Relative Number of Flagged Sessions Corresponding to Flagging of Squat Repetition-Volume During 30% and 20% VLT.



Note: **Same sided** = Both repetitions and variable were flagged >1 Z-score; **Neutral** = neither repetitions nor variable was flagged; **± 1=** Either repetition or variable was flagged between 1-1.65 Z-score; **±1.6**5 = Either repetitions or variable was flagged > ±1.65 Z-score; **Opposite** = Both repetition and variable exceeded ±1 Z-score, but in opposite directions.

3.2: Correlations

Small positive correlations existed between changes in repetition-volume and subjective readiness, CMJ and MPV during 30% VLT sessions (Table 4, all $p < .01$). In the 20% VLT sessions the only significant correlation with repetition-volume was MPV, while all other measures ranged between -.038 and .002. General positive correlations existed between all jumping measures across all sessions. The 10/5RSI displayed the lowest correlation with repetition-volume.

Table 4:

Pearson`s Correlation Matrix of Average Changes from the Individual's Norm During the Three Periods

	n	*M*	*SD*	Subjective	CMJ	SJ	10/5RSI	IMTP	MPV	Reps
				30% Velocity loss threshold with 80% of 1RM						
Subjective	158	-,08	1.14	–						
CMJ	158	-.47m	1.56m	.214**	–					
SJ	158	-.32m	1.46m	.213**	.704***	–				
RSI	152	-.00m/s	.14m/s	.108	.252**	.301***	–			
IMTP	47	-5.9N	20.5N	-.050	-.126	-.105	-.068	–		
MPV	158	0m/s	.022m/s	.203**	.118	.134	.018	.038	–	
Reps	158	0	2.05	.251**	.228**	.122	.001	-.262	.203**	–
				20% Velocity loss threshold with 70% of 1RM						
Subjective	206	.03	1.17	–						
CMJ	213	.44m	1.43m	.144*	–					
SJ	212	.17m	1.49m	.204**	.598***	–				
RSI	204	-.00m/s	.16m/s	-.069	.145*	.144*	–			
IMTP	118	3.2N	18N	-.191*	.022	.001	-.106	–		
MPV	213	0m/s	.02m/s	.014	.176*	.206**	-.027	-.191	–	
Reps	213	0	1.85	-.038	-.015	-.036	-.017	.002	.157*	–

Note: Two-tailed *p* values **p* <.05; ****p** < .01; *****p** < .001; ***n*** = subjects included in analysis; ***M***= Mean change from the norm; ***SD*** = Standard deviation of performance from the norm; **Subjective** = Perceived readiness; **CMJ** = Counter movement Jump; **SJ** = Squat Jump; **10/5RSI** = Reactive strength Index measured through the 5 best out of 11 consecutive jumps; **IMTP** = Isometric mid-thigh pull; **MPV** = Mean Propulsive velocity; **Reps** = Repetition-volume; **m** = meters; **m/s** = meters per second; **N** = Newton (Force).

3.3: Multiple regression analysis

In the 30% VLT sessions, the battery (excluding IMTP) explained approximately 12.4% of the variation in repetition-volume (p <.01). The best three factors during 30% VLT were subjective readiness, CMJ and MPV, explaining 11.5% of total repetition-volume, with a p-value of < .001. In the 20% VLT sessions, a non-significant, approximately 3.4% prediction of repetition-volume was seen by the readiness battery (p = .245, Table 5).

Table 5:

Multiple Regression Analysis of Readiness Measures on Prediction of Repetition-Volume

Fixed effect	**Estimate (R)**	**R Square**	**SE**	**95% CI**		***p***
				LL	**UL**	
1. 30% VLT*	.339	.115	1.94			**< .001**
Constant			.162	-.189	.45	.420
Subjective	.177	.031	.142	.052	.612	**.021**
CMJ	.167	.028	.102	.023	.427	**.023**
MPV	.141	.02	7.39	-.81	28.4	.064
2. 30% VLT	.352	.124	1.95			**.002**
Constant			.165	-.194	.460	.422
Subjective	.186	.035	.146	.061	.636	**.018**
CMJ	.180	.032	.144	.049	.618	**.022**
SJ	-.071	.005	.156	-.45	.166	.364
10/5 RSI	-.053	.003	1.17	-3.13	1.52	.494
MPV	.144	.021	7.59	-.891	29.0	.065
3. 20% VLT	.185	.034	1.86			.245

Note: **30% VLT*** = significant measures from correlation matrix; **30% VLT** = All measures excluding IMTP during 30% VLT sessions; **20% VLT** = All measures excluding IMTP during 20% VLT sessions; **CI** = Confidence interval; **LL** = Lower limit; **UL** = Upper limit

4.0: Discussion

The purpose of this study was to examine the degree of autoregulation occurring in barbell back squats repetition-volume when young ice hockey players utilize Velocity loss-thresholds during in-season. Secondly, to examine the extend readiness could predict repetition-volume during the two velocity loss-thresholds. Thirdly, determine the best readiness battery when applying velocity loss thresholds.

4.1: Autoregulation during Velocity loss-thresholds

The mean repetition-volume performed across the three sets were 15.7 (3.3) and 17.1 (3.5) repetitions for 30% and 20% VLT, respectively. The mean differences between individual`s minimum and maximum repetition-volume were 6.3 and 6.9 after three sets for 30% and 20% VLT. This equaled an increase of about 54% and 52% from minimum to maximum. Caveats to these results are that they are across initial weights and the increases of 2.5kg and 5kg. TE in repetitions performed during 30% and 20% VLT also equaled between 14.7% and 11.4%, respectively. This variance underscores that volume and consequent fatigue differ when employing VLT for BBsq. Prior research found that larger VL-thresholds deems larger individual differences in volume if similar weights or velocities are utilized (Weakley et al., 2020). In this current study, the individual’s repetition-volume also fluctuated more during 30% VL than 20% VL.

Regarding the fact that multiple regression analyses could only predict around 12% and 3% of repetition-volume, addresses the question of what optimal daily volume should be. Optimal measures would catch total fatigue, which again could be used to regulate training. In these analyses the VLTs was treated as the key to determine repetition-volume. While the readiness measures were meant to give an indication of the athlete’s daily readiness to train. Therefore, a regulation in training in the same direction as changes to readiness was expected and would have indicated positive regulation. This brings up the question about the validity of VLT to autoregulate positively and adequately, especially with ≤20% VLT. Perhaps also the readiness measures in giving meanigful answers into how training should be regulated, however that seems more doubtful.

The variation in volume with application of VL thresholds suggests that an autoregulatory mechanism appears. However, robust downregulation during fatigue and upregulation during high readiness seemingly do not happen.

4.2: Best readiness measures during Velocity loss-threshold, and what insight do they give?

Criticism has been put against VL thresholds as the sole reliance regulating method, but encouraged alongside other regulating methods (Guppy et al., 2023). That claim can be backed up by the seemingly sporadic changes in repetition-volume participants performed in this current study. Subjective readiness, CMJ and MPV were the best three measures in predicting repetition-volume during VLT. SJ, 10/5 RSI and IMTP all have theoretical reasoning to be included, however the results indicate they were below par. SJ showed comparable results as CMJ, although being slightly inferior. While 10/5RSI has some good theoretical ground because of the repeated stretch-shortening reflex, the technical execution seems too big of a limitation to be a valid measure. IMTP was included as the only measure for maximal strength, but failed to give conclusive insight, maybe because of the lack of consistency in testing or the “key” placed with VLT.

All mean readiness measures were lower during the harder 30% VL than during the 20% VL sessions, with CMJ and SJ being the most notable ones (-.47m & -.32m; Table 4). This indicates a substantial readiness increase from Tuesday till Friday of approximately 0.36 and 0.29 Z-scores. Hence, subjects in general had adequate rest from the hard session to the easier session, but with some presession-fatigue during the hard sessions, possibly from the weekend matches. Considering that the larger part of these subjects were high school students with sport-subjects, they could also have daily training sessions in school on top of club training.

Flagging of data seemed to be superior to multiple regression into giving meaningful insight into how changes from the norm lead to total repetition-volume during VLT. Because a clearer connection between the measures and repetition-volume became evident when reaching the flagging thresholds during 30% VLT. This could be related to what should be considered a worthwhile change (K. A. Lindberg et al., 2022; Turner, 2022). While the small changes (below 1Z-score) would to a larger extent be due to random testing errors (“noise”; K.A. Lindberg et al., 2022) and possibly impact correlation and multiple regression analysis. In a practical sense, performance flagging could be done pre-and during sessions to alter training. With flagging thresholds of one and 1.65 Z-score, there are risks of being wrong in around 32% and 10% of the time, if one measure alone is considered (Turner, 2022). However, when used as a monitoring tool to assess possible overtraining scenarios, a coach could stay on the side of caution and lower the training strain with a chance of a false negative (Turner, 2022). To mitigate risks of being wrong, a battery of reliable tests as well as more attempts will better the chance of true representation of daily readiness.

4.2.1: Subjective measures

In the meta-analysis of Saw et al (2015) subjective measures seemed to be great at catching acute changes in readiness, contrary to typical lab tests (Blood, urine, saliva). Regarding VBT, Weakley et al (2024) found elite level rugby players to perceive low levels of changed soreness 24 hours after performing five sets of BBsq to 10% VL with mean concentric velocity targets of .70m/s. While performing the same regiment with 20% and 30% VL the perceived soreness was exponentially higher 24 hours later (p <.001; Weakley et al., 2024). Caveats to the comparability of these findings are the number of sets performed, as well as the Mean concentric velocity of .70m/s is faster than the equivalent MPV in this study (Means: .54m/s-.43m/s, Table 1). In a study on recreational cyclist, perceived soreness was a great measure of fatigue and overreaching, where subjects cycled acutely more than usual (≈700%) in a seven-day race (Ten Haaf et al., 2017).

In seven cases, both repetition-volume and subjective readiness had same-sided flagging (Z-Score ≥ 1), which equaled approximately 20% of flagged cases for both variables during 30% VLT. In relation to the normal curve, this would happen approximately 5.1% of the time by pure chance, hence inducing some confidence in pre-session subjective measures. The general small correlation (.251 p < .01) also shows a trend to the same direction. There was only one case of opposite flagging during 30% VLT. In that particular case, the player performed lower repetition-volume (one Z-score lower) while feeling one Z-score above normal, combined with MPV > 1.65 Z-score faster than normal. This case represents the opposite of what is wanted; downregulation while being “ready”. However, the increase in lifting speed might indicate some higher quality of effort, despite the lower repetition-volume. With 20% VL-threshold however, there were no clear correlations between subjective readiness and repetition-volume (-.038), with 2.9% of instances displaying same sided flagging, versus 3.9% exhibiting opposite flagging.

4.2.2: CMJ

From a 90-minute soccer specific test (Loughborough Intermittent Shuttle Test) subjective measures of readiness and soreness changed significantly (p = .02 - .0001) after 24h and 48h, while there were no change in CMJ (Lombard et al., 2021). Although CMJ have seen great reliability, some researcher postulates that changes while fatigued might not exceed the TE, and therefore is not adequate by itself (Vernon et al., 2020). This is concerning if a coach were to solely rely on CMJ to measure readiness. However, during long periods of neuromuscular strain, jumping measures have been deemed effective within athletics athletes (Welsh et al., 2008). This could strengthen the need for larger normative data, rather than short stint pre-post data as displayed by Lombard et al (2021). CMJ as a readiness measure, could be more related to VBT than 1RM percentage-based training, as VBT regiments often display superior gains in power and speed (Banyard et al., 2020; Dorrell et al., 2020). In this current study CMJ had same-sided flags with repetition-volume in 6.3% and 4.2% of the time during 30% and 20% VLT respectively (Figure 2). Opposite flagging was also apparent in 3.1% and 4.7% of the instances during 30%VL and 20% VL. Unfortunately, this indicates larger chances of being wrong than what is preferable. The flagging data and multiple regression analyses (Table 5) do not induce confidence in CMJ on its own in predicting repetition-volume during VLT.

4.2.3: Lifting speed

The use of mean and peak concentric velocities during submaximal warmup sets have been deemed a good readiness measure for BBsq in an earlier study (Vernon et al., 2020). Vernon et al (2020) found that lifting speed with intensities of ≥60% decreased with medium to large effects (d = 0.6 - 1.99) 24 and 48 hours after performing either a strength (5x5 80%1RM) or power program (6x3 50%1RM). Lifting speed in this current study was not used as a pre-session measure of readiness. However, changes in submaximal lifting speeds in the warmup, could have been used as a readiness measure, and thereafter as an autoregulating method for the session. Load-velocity profiles have previously been theorized to be able to determine 1RM without the large neuromuscular fatigue. From a general standpoint the use of current

Load-velocity profiles seems to be off the mark by quite a substantial margin in estimating daily 1RM in BBsq, with overestimations being normal (Guppy et al., 2023). During warmup sets in BBsq, 1RM estimations were roughly overestimated by 20-30kg using transducers (Banyard et al., 2017). If this method had been reliable, VBT as well as typical 1RM percentage-based prescription would have been greatly improved. One could however, interpret velocity as it is, and thereafter determine loads based on bandwidth velocities, rather than daily 1RM estimates (Jovanovic & Flanagan, 2014). Using changes in lifting speed to adjust weights to simulate the intended stimulus (maximal strength to speed-strength) of the session. However, one must consider individual normative data, as different athletes with similar 1RM might lift with different velocities on the same intensities.

MPV was the measure with fewest opposite flags with two cases (1.3%) during 30% VLT and one case (0.5%) during 20% VLT. As well as having nine (5.7%) and 11 (5.2%) same-sided flags, totaling 21.7% shared same-sided flags with repetition-volume across both VLT. This should be encouraging for athletes and coaches wanting to optimize adaptations in the gym, while minimizing the risk of making the wrong decision. With a view of MPV in purely predicting repetition-volume from multiple regression analysis, the measure follows the others of not being valuable. All this considered, changes in lifting speed seem like a valuable measure across different VLT.

4.3: Limitations

A big problem with the design of this study was the size of the moving average periods during the intervention. The moving average for squats were determined based on the individuals' intensities (70% and 80% of 1RM + 2.5kg and 5kg). As each squat period had between two and four sessions, there was not large enough normative data. The mean TE for 30% and 20% VLT were at 14.7% and 11.4%, respectively. As TE were determined when subjects weren't objectively rested (e.g. 48 hours without training), session to session was not representative of what true TE should be. This leads to a problem in detecting meaningful changes, as a meaningful change probably lies within a lower percentage than this TE (K. A. Lindberg et al., 2022). In practice, these high TE% would need the subjects in this study to perform around three and two repetitions from their norms to be flagged in 30% and 20% VL, respectively. With few sessions per period, the norm would also be skewed by anomalies. To counter this problem, the use of the exact same weights would have made data flagging much more concise. As this study was part of a multi-study with planned weight increases, this was not possible. It must also be noted that VBT has the intent of autoregulating repetitions based on performance, hence TE might not be the optimal way of flagging.

Although all subjects performed squats with 30% and 20% VL thresholds, the screen that displayed feedback was not the same. The other part of this project investigated the difference between two types of feedback. One group seeing velocities on screen, versus the other group seeing velocity and velocity loss percentage with color coding (green, yellow, and red). These types of feedback could alter the subjects lifting speed and total repetitions. To counter the influence this could have, the subjects always performed their sets of BBsq with the same feedback throughout the intervention. Another noteworthy distinction between many of the studies and the present study lies in the participants higher 1RM in BBsq (128.7kg ± 20.7kg) as well as the use of freeweights rather than smith machine (Pareja-Blanco, Rodríguez-Rosell, et al., 2017; Pareja-Blanco, Sánchez-Medina, et al., 2017; Rojas Jaramillo et al., 2024). This could potentially impact comparability as well as technique and subsequent applicability in athletic training (Guppy et al., 2023; van den Tillaar & Larsen, 2020).

In general, the subjects in this study gained strength, power, and hypertrophy in the lower limbs, but some subjects had little to no change. Hard training was performed in-season, with no regulation of training based on the readiness measures. In-season generally means larger fatigue, where alteration to resistance training might have had higher value.

4.4: Further research

The adequacy of VLT as autoregulatory mechanisms remains uncertain, especially when utilizing ≤20% VLT. All results between readiness and repetition-volume during 20% VLT indicate random non-connected changes for all measures except MPV. This puts a question mark on what meaningful autoregulation happens during 20% VLT, without questioning the positive training effects (Włodarczyk et al., 2021). ≤20% VLT might regulate fatigue in the sense of it being easy enough when total volume stays relatively low, although not autoregulating in a meaningful way. Reexamination of these findings with both different exercises and other subjects would be good for clarity. A possibility would be an intervention design, where pre-session flagging determines up, - or-downregulation based on set criteria in one group, while another group does the same pretesting but without regulation. The use of normative data within subjective readiness, CMJ and lifting speed in the warmup would be good insight to this present study`s results. As it is important to assess the validity of a readiness measure or the combination, in giving meaningful insight into an athlete's recovery.

More research of readiness assessments with pre-post designs would give meaningful insight into acute fatigue as done by Weakley et al (2024) and Lombard et al (2021). This type of research would be insightful for VBT and sport-specific training. Especially in-season one would want to know how matches and on-ice (or on pitch in other sports) influence the players ability to train and recover in the gym.

How readiness measures correlate with training to failure or a few reps in reserve could give great insight into daily training regulation. Pareja-Blanco, Rodríguez-Rosell et al. (2017) reported that 56% of sets performed at 40% VLT also equaled muscular failure. Similarly, smith machine BBsq performed to failure with intensities of 70-90% equaled VL of 40-50% in elite wrestling athletes (Janićijević et al., 2024). Weakley et al (2020) suggests 30% VLT could be an effective way of objectively prescribing high volume training without reaching failure. In this regard, different reps in reserve corresponding to lifting speeds need further research. As training to failure probably is slightly inferior to a few repetitions in reserve, with less fatigue during high volume training for quadriceps training (Refalo et al., 2024). This could mean that readiness matters more in harder session and should be investigated further.

4.5: Practical applications

The fact that repetition-volume differs immensely from one individual to another, as well as substantial changes within subjects, some general rules should be applied when prescribing VL-thresholds for autoregulating purposes. If one is using an intensity of 80% and strength gains is the target, one could also apply a range of around 3-6 reps per set, on top of the chosen VLT. In this case the set would be terminated at six repetitions even if VLT is not exceeded. This argument have been made earlier, and could offset unwanted fatigue and mixed training outcomes (Guppy et al., 2023). The same stipulations could be applied for speed and power outcomes. Regarding this study, some subjects performed ≈10 repetitions with 80% of 1RM, while maximal strength was the actual goal of the session.

From this study, data flagging would also be good to include when utilizing VLT for autoregulation. This would need either the use of baseline/normative data, or another clear-cut approach. Readiness assessments could strengthen regulation of training for individual athletes. The use of subjective measures seems to be a valuable low—hanging fruit, as it is easy to measure, and gives reasonable insight. One have to be cautious that athletes are not underreporting to get away with mostly easier sessions (Byrkjedal et al., 2023). Lifting speed could be used as pre-session or in-session autoregulation during warmups and working sets. Should there be access to a reliable measurement of CMJ height, this could be helpful if combined with other measures. In what ways one would want to regulate training based on readiness are more speculative. If a large deviation is seen, one could alter the VL-threshold, or add or retract sets. Total recovery demands would then categorically change. Small weight changes (±2.5kg-5kg) could be applied if small up-or down fluctuations in readiness are seen.

4.6: perspective

VLT of ≤20% have been found to be inferior in strength and power adaptations (Włodarczyk et al., 2021). This study challenges the view of looking at it in a strict way. Even though VLT of ≤20% align with wanted adaptations during in-season. Some periods or sessions might deem opportunities to push a bit harder, and thereafter gain a little advantage over competitors. This is where readiness could provide the information of who have the recovery capability to go a bit harder and get even stronger and faster in-season.

While training during the in-season, readiness should be considered to a larger degree than during off- and pre-season. During off and pre-season, one could still monitor athletes' readiness while broadening the data of the individual's baseline and typical fluctuations, but be more lenient if readiness is low, and still push hard. This is because one would still want athletes to build tolerance to strain while also building strength and power. Athletes can tolerate challenging periods without suffering nonfunctional overreaching, as long as volumes, intensities or durations are not excessive (Meeusen et al., 2013).

5.0: Conclusion

Individual`s volume differs when utilizing velocity thresholds of 30% and 20% in free-weight barbell back squat. However, it differs more often in the same direction as readiness during 30% velocity loss-thresholds, but in a random way during 20% velocity loss-thresholds. For repetition-volume autoregulation, velocity loss-threshold of 30% works incompletely on its own, while 20% Velocity loss-threshold work poorly. The best readiness battery includes a subjective measure, despite larger typical errors, as well as an objective measure of lifting speed. The Counter movement jump can be included for a broader battery.

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Part 2: Overbygging

Contents

Utdypende teori

1.1: Autoregulering

Autoregulering omhandler metoder for å justere treningsbelastning basert på fluktuasjoner i prestasjon eller oppfattet prestasjonstro fra dag til dag eller uke til uke (Greig et al., 2020; Mann et al., 2010). Disse metodene kan igjen deles inn i objektiv og subjektiv autoregulering (Larsen et al., 2021). Autoregulering av trening anses som en gunstig måte å justere for ulike former for belastninger, som fysisk (treningsfatigue) og psykisk stress blant topputøvere (Mann et al., 2016). Ved autoregulerende metoder fjerner, eller justerer man automatiske treningsbelastning underveis basert på satte kriterier. Innen styrketrening vil autoregulerende metoder stå i kontrast til å benytte forhåndsdømte En-repetisjon maksimum (1RM) belastninger, repetisjoner og serier (Sheppard & Triplett, 2016). Innen styrketrening er Repetisjoner i Reservere (RIR) til Rating of Percieved Exertion (RPE) metoden, Autoregulatory Progressive Resistance Exercise (APRE), fleksibel ikke-lineær periodisering (FNP) og ulike hastighetsstyrte styrketreningsmetoder (VBT) identifisert som typiske autoregulerende metoder (Larsen et al., 2021).

1.1.1: RIR til RPE metoden

På 60-tallet ble RPE-skalaen utredet for å vurdere opplevd innsats (Borg, 1962). RPE er en vanlig måte å rangere innsats, samt subjektivt autoregulere trening i forhold til opplevd nærhet til absolutt anstrengelse (Borg, 1970). Borgs skala er typisk benyttet innen utholdenhetstrening, men ble tidlig på 2000-tallet validert med tanke på styrketrening (Robertson et al., 2003). RIR til RPE metoden er utredet med klarere definisjoner ved vurderingene (Zourdos et al., 2016). Metoden regulerer innsats i forhold til muskulær utmattelse (Helms et al., 2017). Med muskulær utmattelse menes det at til tross for full innsats går ikke den konsentriske fasen av løftet lenger, og muskelaksjonen blir isometrisk eller eksentrisk (Helms et al., 2016). RPE rangeres fra 1-10, hvor 10 er maksimal innsats, og en kunne hverken utført flere repetisjoner eller benyttet tyngre belastning (Greig et al., 2020). RIR forteller om hvor mange ekstra repetisjoner man kunne ha løftet (Greig et al., 2020). Ved RPE brukes også halve scorer, som 9.5 eller 8.5. Der betyr 9.5 at en trolig kunne løftet en litt høyere belastning for like mange repetisjoner, men ikke fått til flere repetisjoner på benyttet belastning. RPE 8.5 betyr at en kunne løftet 1-2 flere repetisjoner før teknisk og muskulær utmattelse. Jo lavere RPE og flere RIR en kommer til blir det vanskeligere å estimere riktig, og det er vanlig å underestimere antall RIR (Hackett et al., 2012; Halperin et al., 2021). Studier har sett liknende resultater på hypertrofi ved styrketrening utført til muskulær utmattelse mot fåtall av RIR blant trente og utrente (Refalo et al., 2022; Refalo et al., 2024). Neuromuskulær fatigue er vist å være høyere ved quadtriceps trening utført til muskulær utmattelse (Refalo et al., 2024). I studien av Refalo et al (2024) sammenlignet de to grupper som begge utførte moderat til høyt treningsvolum over 8 uker. Der begge gruppene utførte like mange serier på øvelsene leg press og leg extension, men hvor en gruppe løftet alle serier til muskulær utmattelse. Den andre gruppen utførte alle seriene ved leg press til 1 RIR og 2 RIR ved leg extensions (Refalo et al., 2024). RPE-skalaen og løftehastighet har også vist seg å korrelere, ved høyere opplevd RPE kommer også lavere hastigheter på løftene (Zourdos et al., 2016).

1.1.2: Autoregulatory Progressive Resistance Exercise (APRE)

Flere APRE-programmer har blitt utviklet siden 40-tallet, hovedsakelig med fokus på rehabilitering ved skader (Potach & Grindstaff, 2016). Sentrale konsepter ved flere av disse programmene er «en repetisjon maksimum (1RM)», «Repetisjoner maksimum (RM)», «muskulær utmattelse» og «as many reps as possible (AMRAP)». Der 1RM er den maksimale vekten en kunne løftet bare en gang, mens RM er det maksimale antall repetisjoner man kunne utført med en gitt belastning (Edgerton, 1976). For eksempel dersom man klarte å utføre 6 repetisjoner med 100kg på knebøy, men ikke en syvende repetisjon, er 6RM-en 100kg. Ved både 1RM og RM kreves det at teknikken ikke frafaller under forsøket (Edgerton, 1976). Disse konseptene er vesentlig for hvordan progresjonen automatisk skal være ved APRE-program.

Det første autoregulerende treningsprogrammet i litteraturen er Delorme sitt Progressive Resistance Exercise (PRE) program (Delorme, 1945). Ved programmet utførte man 10 repetisjoner med progressivt tyngre og tyngre belastninger basert på estimerte prosentandeler av 10RM. Autoregulering ble gjort fra uke til uke for nye estimater av 10RM (Delorme, 1945). Metoden Daily adjustable progressive resistive exercise ble senere utviklet av Knight (1979) som bygget videre på konseptet til Delorme (1945). Ved Knight programmet utføres første serie på 10 repetisjoner med 50% av estimert 1RM, andre serie på 6 repetisjoner ved 75% av 1RM og tredje serie med AMRAP med 100% av estimert 1RM (Knight, 1979, 1985).

Skulle man klare flere enn seks repetisjoner med den estimerte 1RM, økes vekten for den siste (fjerde) serien, samt skulle man klare over 4 repetisjoner økes neste økt sitt estimat av 1RM (Knight, 1985). Andre metoder er utrettet med samme konsept, der autoregulering gjøres baseres på antall utførte repetisjoner ved AMRAP (Huang et al., 2023; Mann et al., 2010).

Ved studien av Mann et al (2010) ble det utført en intervensjon med to grupper. En gruppe benyttet et tredelt APRE-program basert på estimater av 3RM, 6RM eller 10RM hvor den tredje serien utførtes det AMRAP, for så å regulere den fjerde serien etter satte stipulasjoner (Mann et al., 2010). Kontrollgruppen utførte tradisjonell lineær periodisering med repetisjonsrekkevidden 5-8 på mellom 70% og 85% av 1RM. Ved denne undersøkelsen fungerte APRE signifikant bedre ($p < .05$) enn tradisjonell periodisering for maksimal styrke i knebøy (Mann et al., 2010). APRE fungerte signifikant bedre for maksimal og utholdende styrke ved benkpress (begge p =.02), men APRE-gruppen var også signifikant svakere ved baseline (Maksimal, $p < .01$ og Utholdende, $p = .02$; Mann et al., 2010). I forhold til et VBT-program med 10% hastighetsfall fungerte et APRE-program med liknende stipulasjoner signifikant ($p <.01$) bedre pre til post i svikthopp (Huang et al., 2023). Begge gruppene utførte knebøy basert på estimater av RM og 1RM.

1.1.3: Fleksibel ikke-lineær trening (undulating periodization)

Ved fleksibel ikke-lineær periodisering vil treningsmetoder mikses, gjerne annenhver økt hypertrofi og maksimal/eksplosiv styrketrening (Kraemer & Fleck, 2007). Satt ut i praksis blant idrettsutøvere, vil gjerne utradisjonelt korte pausetider også benyttes dersom idretten selv krever spesifikke energisystemer (Kraemer & Fleck, 2007). Kraemer & Fleck (2007) eksemplifiserer med flere serier knebøy med 10RM belastning og ≤1minutt pause for basketballspillere, ettersom de utfører gjentatte sprinter uten å få fullstendig fylt opp kreatinfosfat i musklene. Dette kan også relateres til ishockey, hvor det også kreves så mye kraftproduksjon som mulig over litt lenger perioder enn hva kreatinfosfat bringer. Allikevel vil hovedkonseptene ved styrketreningen (hypertrofi, maksimal styrke og eksplosiv styrke) i løpet av året bestå.

Ved fleksibel ikke-lineær periodisering er allikevel hoved essensen at repetisjoner, intensitet og belastning kan variere fra økt til økt, blant annet på grunn av konseptet daglig readiness (Fleck, 2011; Haff, 2016). Der tester før og underveis i øktene, måler opp endringer ved prestasjonene for å bedømme daglig fatigue og total readiness (Kraemer & Fleck, 2007). Skulle en negativ endring oppdages ved en øvelse, senkes intensiteten eller volumet for denne øvelsen, og neste øvelse går som normalt (Kraemer & Fleck, 2007). Dette er for å vurdere om det er mental eller muskulær fatigue, lokale muskelgrupper eller en kombinasjon av muskelgrupper som presterer under norm (Kraemer & Fleck, 2007). Ofte benyttes høyere intensiteter og/eller flere serier dersom man presterer bedre enn normalt, og lavere intensiteter og flere repetisjoner dersom man skårer lavt (Fleck, 2011).

1.2: Readiness

Readiness er et komplekst begrep, men som inngår under individers klarhet for å mestre kravene for enhver oppgave som oppstår. Begrepet er blitt brukt bredt i litteraturen, uten at en klar konsensus er blitt funnet (Greig et al., 2020; Strohacker & Zakrajsek, 2016). Gjennom forskning i militære sammenhenger trekkes en fysisk og mental readiness frem (Koltun et al., 2022; Nindl et al., 2013). Under militære opphold er det fysisk trening og idrett som leder til flest legebesøk etter muskel- og skjelett skader (A.F.H.S.D, 2012, 2022). Militær fysisk readiness ble definert som en kombinasjon av «*menneskelig prestasjonsoptimalisering og skadeforebygging*» (Nindl et al., 2013, s. 6). For treningsrelatert readiness bør trolig både fysiske og psykiske faktorer inkluderes (Strohacker & Zakrajsek, 2016). Ved trening, inngår readiness som en del av autoregulering, hvor Greig et al (2020) bryter readiness ned til hovedsakelig søvn, ernæring og sykdom. Logiske faktorer som skadestatus, hydreringsstatus og kroppsvekstfluksjoner har også blitt inkludert inn i begrepet (Kraemer & Fleck, 2007). Andre inkluderer også de negative faktorene ved trening (fatigue), samt normale uforklarlige dagsvariasjoner inn i vurderingen av readiness (Jovanovic & Flanagan, 2014; Kraemer & Fleck, 2007). Det forsøkes å komprimere faktorene ned til praktiske og målbare måter ved ulike populasjoner etter at Kelley & Zakrajsek (2016) inkludere et bredt spekter av variabler inn i faktor analyser.

Readiness kan være en viktig predikator for prestasjonsendringer for utøvere som er svært godt trente (Greig et al., 2020). Kraftplattformer kan benyttes for å monitorere readiness, hvor tester kan måle neuromuskulær fatigue uten å bruke like belastende tester som 1RM (Merrigan et al., 2020; Silva et al., 2018). For å måle readiness kan forskjellen mellom prestasjon og forventet prestasjon gjøres, med en basis av at man har noe normativ data på individets prestasjon (Greig et al., 2020). Videre kan regulering av trening automatisk gjøres, da altså gjennom autoregulering.

1.2.1: Subjektiv readiness versus objektiv readiness

En oversiktsartikkel av Saw et al (2015) fant at opplevd stress hang godt sammen med negative fysiske prestasjoner. Objektive mål var hovedsakelig relatert til hormonmålinger og ikke-fysiske tester (Saw et al., 2015). Ved undersøkelser av endringer ved CMJ og et subjektivt spørreskjema (Readiness-to-train) ble det funnet at svekket subjektiv readiness ($p < .05$) oppstod før CMJ endringer (Lombard et al., 2021). Dette ble etter en intervensjonsgruppe utførte en Loughborough Intermittent Shuttle Test, og gruppen opplevde signifikant mer subjektiv fatigue etter 24 og 48 timer selv om hopphøyde og kraftutvikling var uendret (Lombard et al., 2021). En test som ved Loughborough Intermittent Shuttle Test prøver å vise sammenheng med hvordan typiske trening og kampsituasjoner i idrett kan innvirke readiness på kort og medium sikt. Ved knebøy utført til 10%, 20% og 30% hastighetsfalls-terskler viste signifikante reduksjoner i CMJ etter femte (siste) serien av knebøyen var tatt ($p < .001$), men ikke signifikante endringer etter 24 timer ved noen av gruppene (Weakley et al., 2024). Subjektive mål er generelt bedre i å oppdage akutte endringer, mens objektive mål delvis oppdaget negative endringer (Saw et al., 2015). Subjektiv autoregulering basert på egen vurdering av restitusjon og readiness er allikevel hypotisert å kunne føre til undertrening ved stort treningsvolum, spesielt i sesong (Byrkjedal et al., 2023). Dette er basert på utøvernes preferanser innen styrketrening, det vil si at utøvere som får valg mellom en lettere eller tyngre økt muligens i større grad velger det lette valget (Byrkjedal et al., 2023). Allikevel virket en objektiv autoreguleringsmetode basert på høy intensitetsløping i kamp å fungere tilsynelatende likt som en subjektiv reguleringsmetode da lavt styrketreningsvolum var inkludert i sesong for profesjonelle fotballspillere (Byrkjedal et al., 2023). Subjektive vurderinger virker generelt å være mer sensitive enn objektive readinesstester (Lombard et al., 2021; Saw et al., 2015; Weakley et al., 2024).

1.3: Styrketrening

Styrketrening benyttes for å fremme prestasjon gjennom gradvise fysiologiske adaptasjoner (Haff, 2016). Ved styrketrening brytes muskulatur ned under trening og bygges opp, samt litt større og bedre ved nok restitusjon. Nedbrytningsprosesser kalles katabolisme, mens oppbygningsprosesser kalles anabolisme, ved muskeloppbygging kalles det en endergonisk reaksjon (Herda & Cramer, 2016). Muskelstyrke bestemmes av flere faktorer: muskeltverrsnitt, muskelfibersammensetning, musklenes utspring og festet og nervesystemets evne til å aktivere og styre musklene kan anses som de viktigste (Cormie et al., 2011; Raastad, 2007). Type II fibre (IIa og IIx) er vist å kunne produsere raskere muskelkontraksjoner og dermed danne større maksimal kraft (F_{Max}), power (P_{Max}) og fart (V_{Max}; Cormie et al., 2011). Evnen til å utføre ulike løft og bevegelser innvirkes også i stor grad av teknikk (Raastad, 2007). Toppidrettsutøvere har ofte en hensikt å øke den maksimale muskelstyrken, men spesielt den eksplosive styrken (Refsnes, 2007). Eksplosiv muskelstyrke (power) er evnen til å produsere størst mulig kraft over kort tid (McGuigan, 2016a), som kan være avgjørende i ishockey (Burr et al., 2008). Evnen til å opprettholde høy power over tid ble funnet å henge godt sammen med ishockeyprestasjon, spesielt for forsvarsspillere (Burr et al., 2008). Produksjon av power kan forbedres gjennom øking av maksimal kraftproduksjon eller maksimal fart på bevegelsene (Cormie et al., 2011). Ved eksplosiv styrketrening er hoved essensen å skape mest mulig fart på bevegelsen og kan benytte et bredt spekter av intensiteter (Sheppard & Triplett, 2016). Fra høy intensitet mellom 75% og 90% av 1RM ved olympiske løft, eller med lav til ingen ekstern belastning, ved ballistiske eller plyometriske øvelser (Potach & Chu, 2016; Sheppard & Triplett, 2016).

Styrketrening blir som regel oppsatt gjennom et periodiseringsregime. Tradisjonell periodisering blir ofte kalt lineær periodisering, og innebærer en årsplan eller makrosykluser bestående av flere mesosykluser med predeterminerte hovedmål (Haff, 2016). Innen toppidretten er det vanlig å operere med en årsplan basert på hoveddelene i sesongen; 1. off-season, 2. preseason, 3. in-season og 4. post season. I disse delene er et vanlig å fokusere på 1. hypertrofitrening, 2. maksimal og eksplosiv trening, 3. likt som 2 (pre-season), men med mindre volum og 4. aktiv restitusjon til til off-season starter igjen (Haff, 2016). Haff (2016) kritiserer at tradisjonell periodisering ofte forstås synonymt med «lineær periodisering», ettersom det kan benyttes ikke-lineære progresjoner til tross av de predeterminerte målene. Trening for hypertrofi vil generelt benytte intensiteter mellom 67% og 85% av 1RM og repetisjonsrekkevidden 6-12, mens maksimal styrke ofte benytter 85% av 1RM eller over, samt opptil 6 repetisjoner (Sheppard & Triplett, 2016). Ved en metaanalyse ble det funnet at styrketrening og utholdenhetstrening samtidig (kombinasjonstrening) var mindre effektivt for å øke maksimal og eksplosiv styrke, enn bare styrketrening for seg selv (Huiberts et al., 2023). Dette setter lys over hvorfor periodisering er hensiktsmessig for topputøvere, spesielt om det er krav til svært ulike egenskaper.

1.4: Hastighetsstyrt styrketrening

Hastighetsstyrt styrketrening (VBT) benytter hastigheten på løftene for å styre repetisjoner, belastning, spesifikke treningsadaptasjoner eller en kombinasjon av disse. VBT har kommet frem som en objektiv autoreguleringsmetode ettersom treningsvolum som regel ikke er forhåndsdømt (Mann et al., 2015; Weakley et al., 2021). Vanlige metoder ved VBT benytter enten hastighetsmål eller gitte hastighetstasfall (Hirsch & Frost, 2019; Jovanovic & Flanagan, 2014). Ved hastighetsmål utføres alle repetisjoner i en gitt hastighetsrekkevidde basert på treningens mål, som maksimal styrke eller ekspolsiv styrke (Dorrell et al., 2020; Weakley et al., 2021; Weakley et al., 2020). Ved hastighetstap settes en prosentvis endring fra raskeste repetisjon til siste repetisjon når hastighetstapsterskelen. Ved hastighetsmål avsluttes serien når repetisjonen faller utenfor hastighetsrekkevidden, akkurat som ved hastighetstaps-terskler. Belastning bestemmes derfor av farten på løftene, i motsetning til hastighetsfalls-terskler hvor farten i stor grad bestemmes av belastningen.

Ved tidligere anledninger er det funnet å være mest gunstig å bruke hastighetstap mellom 10% og 20% for eksplosiv og maksimal styrke progresjon (Wlodarczyk et al., 2021). For å opprettholde reliabiliteten ved gitte hastighetstap kreves det at deltakerne utfører repetisjonene så raskt som mulig. En studie har derimot trukket frem fordeler med å sette mål om hastighetsrekkevidder kontra "så raskt som mulig" for å opprettholde teknikk kvaliteten og mer varige hastigheter (Hirsch & Frost, 2019). Hastigheten på løftene ved disse metodene bestemmes oftest gjennom gjennomsnittlig konsentrisk hastighet eller gjennomsnittlig fremdrivende hastighet (MPV). Forskjellen ligger ved at MPV inkluderer den konsentriske delen som akselerer fortere enn gravitasjonskreftene (Sanchez-Medina et al., 2010). I praksis betyr det oftest å ekskludere bremsingen rett før topposisjonen, spesielt ved lettere belastninger (Sanchez-Medina et al., 2010).

Det er blant annet noen fysiologiske grunner til at løftene gradvis vil falle fra repetisjon til repetisjon (Weakley et al., 2020). Fatigue er funnet å først oppstå ved musklenes evne til å produsere kraft, etterfulgt av mangelfullt med kalsiumioner (Ca^2) som pumpes inn i muskelcellene (Westerblad et al., 1998). Ved gitte hastighetstap benyttes prinsippet om muskeltretthet, i den forstanden at ens evne til å opprettholde maksimalkraft svekkes (Raastad, 2007) som derfor fører til en gradvis reduksjon i hastigheten på løftet. Dette relateres til tømming av kreatinfosfat, etterfulgt av økt Ph-verdi (melkesyre) i muskulaturen ved økende varighet av energisystemet rask glykolyse (Herda & Cramer, 2016). Fra serie til serie og repetisjon til repetisjon vil en balanse mellom manglende kalsiumioner (Ca^2) i den aktuelle muskulaturen og pausetid på toppen kunne påvirke ens teoretiske maksimale kraft (Westerblad et al., 1998).

I en studie av Pareja-Blanco, Rodríguez-Rosell, et al (2017) så dem på forskjeller mellom to grupper som utførte smith machine knebøy med henholdsvis 20% og 40% hastighetstap-terskler. Ved undersøkelsen kom det frem blant utvalget at gruppen som trente til 20% hastighetstap-terskel økte sin maksimale og eksplosive styrke i underekstremitetene bedre enn gruppen med 40% hastighetstap-terskel (Pareja-Blanco, Rodríguez-Rosell, et al., 2017). De største muskeltverrsnitts forskjellene ble derimot oppnådd av gruppen som utførte til 40% hastighetstap-terskelen (Pareja-Blanco, Rodríguez-Rosell, et al., 2017). Pareja-Blanco, Rodríguez-Rosell, et al (2017) konkluderte med at 20% hastighetstap-terskel var mer gunstig for atletisk prestasjon enn 40% hastighetstap-terskel ved knebøy.

Ved en undersøkelse mellom 15% og 30% hastighetstap-terskler ved smith machine knebøy kom 15%-terskelen best ut (Pareja-Blanco, Sánchez-Medina, et al., 2017). Utøverne var elitespillere i fotball under sesong. De trente 3 økter i uken med belastninger fra 50-65% av 1RM, hvor 2 av øktene benyttet 3 serier og 1 av øktene benyttet 2 serier. Totalt volum var for både 15% og 30% gruppene 8 serier i uken og totalt 251.2 ± 55.4 repetisjoner og 414.6 ± 124.9 repetisjoner i de respektive gruppene (Pareja-Blanco, Sánchez-Medina, et al., 2017). I denne undersøkelsen viste den lettere (15% hastighetsap-terskelen) økten signifikant ($p < .05$) bedre CMJ endringer over den tyngre økten (Pareja-Blanco, Sánchez-Medina, et al., 2017).

Individualisering av treningsprogram for å endre kraft – fartsprofiler (FV-profil) har de siste årene blitt mer undersøkt. Dette gjøres for å balansere FV-profilen til å utvikle eksplosiv styrke og/eller maksimal styrke og dermed oppnå en generell bedring i atletisk prestasjon, som vertikal hopphøyde (Jiménez-Reyes et al., 2017; Lindberg et al., 2021). Undersøkelser har sett fordeler ved å individualisere treningsprogram for å balansere FV-profilen kontra vanlig balansert styrketrening (Jiménez-Reyes et al., 2017; Jiménez-Reyes et al., 2019; Simpson et al., 2021). Individualisering av treningsprogram basert på FV-profil betyr å inkludere større grad av eksplosive øvelser for utøvere med større grad av maksimal styrke (F_{Max}) enn eksplosiv styrke (P_{Max}) og vice versa.

I en studie av Jiménez-Reyes et al (2017) delte de deltakerne inn i typisk eksplosive og maksimale utøvere. Dette ble bedømt av FV-profiler som ble dannet fra prestasjoner ved knebøyhopp med og uten ytre belastninger. Etterpå delte de gruppene inn i 1. individualiserte program og 2. balanserte program. Et individualisert program ville bety typisk eksplosiv trening (høy hastighet, lav intensitet) for deltakerne som var bedre maksimalt, og maksimal trening (høy intensitet, lav fart) for utøverne som var bedre eksplosivt. Kontrollgruppen var en miks av begge profilene, og utførte et balansert program med begge typer. Treningen ble utført over en 9 ukers intervensjon. Gruppeforskjeller mellom individualiserte versus balansert treningsprogram viste seg å være av moderat effekt (ES = .73 100/0/0; Jiménez-Reyes et al., 2017). Allikevel bør man være sikker på hva som skal prioriters, ettersom et balansert program med omtrent like mye maksimal og power trening ga bedre total fremgang ved en annen undersøkelse (Lindberg et al., 2021).

1.5: Styrketrening blant unge

Når en arbeider med barn og unge kan man møte på store kroppslige forskjeller til tross for liknende kronologisk alder kan muskulaturen og skjelettet variere stort (Lloyd & Faigenbaum, 2016). For å vurdere likealdrede opp mot hverandre kan det være hensiktsmessig å bedømme ved biologisk alder (Lloyd & Faigenbaum, 2016). Spesielt under de største høydevekst periodene er idrettsaktive barn og ungdom utsatt for skader (van der Sluis et al., 2015). For gutter oppstår denne høydeveksten generelt ved 14års alderen (Lloyd & Faigenbaum, 2016).

Kroppens ben og ledd er ikke alltid fullstendig vokst sammen før tidlig i 20-årene (Lloyd & Faigenbaum, 2016). Generelt anses styrketrening som et godt tiltak for å unngå skader, men riktig trening og teknikk kan gjerne være enda viktigere blant unge utøvere (Faigenbaum & Myer, 2010; Keiner et al., 2013; Potach & Grindstaff, 2016). Overbrukskader blant unge kan gjerne oppstå ved stort treningsvolum, som ved fotballtrening og styrketrening kombinert (DiFiori et al., 2014). Det samme kan trolig overføres til ishockey, ettersom det er liknede krav blant annet ved energisystemene (French, 2016). Hockey er funnet å være en av de mer skadeprevalente idrettene blant barn og unge (Emery, 2003). Faigenabum & Myer (2010) anser inadekvat oversyn fra kvalifiserte trenere eller mangelfull løfteteknikk som de største årsakene til skader under styrketrening blant unge. Allikevel er en 1RM i knebøy på to ganger kroppsvekt ansett å være et oppnåelig og hensiktsmessig mål for unge eliteutøvere mellom 16 og 19 år (Keiner et al., 2013).

Det anbefales velbalanserte styrketreningsprogrammer hvor god teknikk blir ivaretatt, for å optimalisere barne-og ungdomsutøvere sin fremdrift og unngå skader (Faigenbaum et al., 2016). 29% av unge idrettsutøvere (11-18år gamle) selvrapporterte å ha vært gjennom en eller flere ikke-funksjonelle overreaching eller overtreningsperioder i løpet av karrieren (Matos et al., 2011). Prevalensen viste seg å stige ved høyere nivå, med nasjonalt nivå og internasjonalt nivå på 37% og 45% (Matos et al., 2011). Under disse periodene ble det blant annet rapportert høyere prevalens av skader, stølhet, søvnproblemer og stagnasjon/regresjon av treningsbelastning med alphaverdi på < .01 (Matos et al., 2011).

1.6: Overtrening og overreaching

I litteraturen finner man mange ulike begreper som omhandler overtrening og trøtthet, som påvirker over kort og lang sikt (Kreider et al., 1998). Undertrening, overreaching og overtrening kan anses å være på et spekter, men klare diagnoseringskriterier for overtrening finnes ikke (Meeusen & De Pauw, 2018; Meeusen et al., 2013). Ønskelige mål på overtrening er lette å måle, kreve submaksimale innsatser, lite kostbare og ikke for invaderende (Meeusen et al., 2013). Overtrening og overeaching kan oppdages gjennom negative prestasjonsendringer over tid (Kreider et al., 1998). Den tydeligere distinksjonene mellom overtrening og overraching kan oppdages retrospektivt ettersom overtrening kan kreve uker til måneder til individet er tilbake til baseline, mens overreaching krever dager til noen uker

(Kreider et al., 1998). Ved overreaching trekker Kreider et al (1998) frem, at det er kombinasjonen av treningsrelaterte og ikke-treningsrelaterte variabler fører til overreaching, mens overtrening kan også oppstå helhetlig fra en av grunnene. Ved ikke-treningsrelaterte variabler menes det stress i livet som ikke bindes til adaptasjoner ved trening, som for eksempel: psykisk helse eller individers personlige relasjoner. Ved overreaching og overtrening er det ikke sikkert man klarer å måle forskjellen fra baseline gjennom verken fysiologiske tester eller psykologiske tegn på utbrenthet (Kreider et al., 1998).

Overtreningstilstand har blitt oppdaget etter bare noen dager med trening, dersom utøvere konkurrerer og trener med stort treningsvolum (Kraemer & Nindl, 1998). Ved undersøkelsen av Kraemer & Nindl (1998) ble tap av kroppsvekt, grepstyrke og isometrisk styrke oppdaget etter noen dager, mens kraftutvikling var uendret. Overtrening ble første gang utført i en laboratorium setting ved en knebøyintervensjon, hvor overtreningsgruppa utførte 10 daglige 1RM ved 100% intensitet, samt leg extension tester på lørdager og utholdende knebøytest på søndager i 2 uker (Fry et al., 1994). Overtreningsdeltakerne ble i 8/11 tilfeller signifikant ($p <$ .05) svakere på knebøyapperatet. Kroppssammensetning forble uendret, mens kreatine kinase konsentrasjoner ble signifikant ($p < .05$) forhøyet på gruppenivå. Kontrollgruppen (n=6) forble uendret over eksperimentet. De konkluderte med at det var store forskjeller i hvor mye trening individer tåler. Ved overtrening klarere ofte utøvere å starte treningsøkten som vanlig, men faller av, eller klarer ikke å fullføre med normal intensitet eller treningsvolum (Meeusen et al., 2013). Maksimal styrke pleier å opprettholdes bedre ved tegn for overtrening, mens eksplosive øvelser som sprint og hopp frafaller fortere (Meeusen et al., 2013).

Funksjonell overreaching er en periode med midlertidige svekkelser av prestasjoner i liknende grad som overtrening, men etter en kort periode (noen dager) med relativt lite treningsbelastning fører til en bratt øking over baseline (Fry, 1998). Ikke funksjonell overreaching er vanskeligere å diagnotisere ettersom det bærer like symptomer som overtrening, men ikke er like langvarig (Meeusen et al., 2013). Funksjonell overeaching er normalt å programmere inn i treningen for å oppnå superkompensasjon ved viktige konkurranser (Meeusen et al., 2013). Kraemer & Nindl (1998) så store fordeler ved å implementere en hviledag, dette konkluderte de med etter god økning i kraftproduksjon etter hviledagen.

1.6.1: Fitness-Fatigue modellen

Fitness-Fatigue modellen setter spekteret mellom undertrening til overtrening basert på 3 faktorer. Modellen forteller om hvordan treningsøkter og treningsblokker innvirker en utøvers prestasjoner positivt (Fitness), og negativt (Fatigue) over tid (Haff, 2016). Akutte endringer i prestasjon forklares av den tredje faktoren "Preparedness" som svekkes etter trening, og når toppen ved fullstendig restitusjon (Haff & Haff, 2012). Preparedness kan muligens måles ved readiness tester. Fitness-Fatigue modellen kan anses som en utvidelse av General Adapatation Syndrome (Chiu & Barnes, 2003; Haff, 2016). Ved bruk av Fitness-Fatigue modellen i praksis bør man ta hensyn til hvordan ulike utøvere oppfatter treningsbelastning og hvordan dette kan føre til ulike fitness og fatigue nivåer (Vermeire et al., 2022).

2.0: Utvidet metodisk diskusjon

2.1: Pilottesting

For å sikre gjennomførbarhet av datainnsamlingen, ble readinessbatteriet testet ved to anledninger, samt readiness og knebøyintervensjonen ved ytterliggere en anledning før prosjektstart. Dette ble gjort for å bestemme antall forsøk i hver test og effektivisere tidsbruken. Pilottestingen ble utført med samme apparater, og grupper på 3 personer. Basert på pilottestingen ble det bestemt at det ikke kunne gis to forsøk på 10/5 RSI og IMTP. Videre ble kalk testet på piloten, og innført fra og med baseline økt 2. Pilottestingene førte også til bedre rutine blant testlederne. Readiness batteriet og knebøy ble satt opp etter en gunstig test rekkefølge med generell og spesifikk oppvarming (McGuigan, 2016b). Etter pilotundersøkelsene ble den originale visningen av RSI modifisert via programvare endring, slik at gjennomsnittet av de beste 5 hoppene ble vist på skjermen automatisk.

2.2: 1RM knebøy testprotokoll

For knebøy treningen var testing av 1RM sentralt å utføre for å sette belastning ved 30% og 20% hastighetsfall-øktene. Pretesten av 1RM ble overvåket og godkjent av trenerne i klubben og studentene. Sikkerhetsarmer ble benyttet under bunnposisjon. Mellom 1-3 spottere ble benyttet ved forsøkene, hvor en spottet bak, og en ved hver side av baren. Trenere i klubben og studentene godkjente løft ved pre og post test. Et godkjent forsøk var tiltenkt femur parallelt med gulvet, men noen avvik ble observert på tvers av testlederne. Ulike dybder ble derfor godkjent, hvorav flest uteliggere over parallell, men også noen under. Dybden som deltakerne utførte ved 1RM testingen var deretter også tilsvarende dybden utført ved starten av den inkluderte intervensjonen. Dette kan ses på som god validitet, (McGuigan, 2016b) men under intervensjonen ble dybde forbedret ved et flertall av deltakerne, som en del av fysisk trener sitt ønske. Bedringen var spesielt relatert til uteliggerne som utførte pretest litt over parallell. Denne endringen vil ha påvirket retest-reliabiliteten ved posttest. Ved dypere knebøy vil også 1RM være lavere og derfor ble gjerne benyttet belastning i realiteten litt høyere enn 70% og 80% av 1RM.

2.3: Validitet og reliabilitet ved instrument og testbatteri

Ved målinger av data for å vurdere prestasjoner er det viktig at både måleverktøyene og testene er valide i å måle hva det skal, også kalt validitet (McGuigan, 2016b). Ved denne undersøkelsen var readiness testbatteriet sammen med MPV ansett som måleren av prestasjon i knebøy, målt ved antall repetisjoner. For at en test eller testbatteri skal være bra, må testen kunne ha overføringsverdi til prestasjonen, samt være reliabel, altså gi konsise svar fra gang til gang (K. A. Lindberg et al., 2022; McGuigan, 2016b). Videre diskuteres målemetoden (Alphatek power plattform) og readiness batteriet.

2.3.1: Alphatek power plattform

Alphatek kraftplattform benytter et knebøystativ oppsatt foran plattformen, kombinert med en 50 tommers flatskjerm som viser umiddelbar feedback (Se Vedlegg 6). Plattformen kan enkelt kobles sammen med mobil eller pc, hvor ulike feedback funksjoner kan inkluderes. Kraftplattformen har tidligere blitt benyttet ved to masteroppgaver og to bacheloroppgaver (Alvaro, 2023; Liverød, 2023; Nyquist, 2023; Remme, 2023), men ingen fagfellevurderte studier. Alphatek power plattform benytter kraften mot underlaget når den beregner alle verdier, som kraft, dybde og MPV, ettersom endringer i kraften mot underlaget vil gjenspeile akselerasjonen av massemiddelpunktet. I motsetning til stanghastighet, vil ikke massemiddelpunktet ha like store utslag i frontal og sagitalplanet som målinger av stanghastighet. Fra bacheloroppgaven til Alvaro (2023) kommer det frem at Alphatek kraftplattform underestimerer løftehastigheter i forhold til stanghastighet. Det gjaldt også til en viss grad i forhold til 3D motion undersøkelser. Dette er ikke unaturlig, ettersom det er forskjellige målemetoder, og trenger ikke nødvendigvis å innvirke prosentvise endringer. Bacheloroppgaven til Alvaro (2023) referer til en upubliserte undersøkelser utført av Olympiatoppen, som undersøkte alphatek plattformen versus Vald Force platform system (Vald performance; Pty Ltd, Newstead QLD, Australia). I denne undersøkelsen viste Alphatek å beregne lavere hastigheter i forhold til Vald kraftplattformen. Ettersom det ikke har blitt utført noen fagfellevurderte undersøkelser av reliabiliteten til plattformen bør man ta stilling til om mulige feilmålinger kan innvirke resultatene. Spesielt ved faktiske hastighetsfalls-terskler ved 20% og 30%, ettersom feil der kan innvirke de viktige resultatene.

2.3.2: Subjektiv readiness

For å vurdere utøveres opplevde restitusjon har spørreskjemaet fra Laurent et al (2011) tidligere blitt benyttet for å måle restitusjon på testdager. Spørreskjemaet byr på veiledning for at deltakerne skal forstå og er lite tidskrevende. Det deles inn i 3 hoveddeler basert på om man forventer å prestere over-, under- eller som normalt. Forventet prestasjon er identifisert ved 0-2 som «under», 3-7 som «normalt» og 8-10 som «over». Ved analysene i denne studien ble allikevel bare tallverdien benyttet, og ikke de nevnte kvalitative beskrivelsene. Ettersom spørreskjemaet omhandler opplevd restitusjon og ikke spesifikt readiness, er det blitt kritisert å til å gjerne være ugunstig ved måling av readiness (Strohacker & Zakrajsek, 2016). Spørreskjemaet er heller ikke validert på norsk. Se Vedlegg 8 for spørreskjemaet.

2.3.3: Svikthopp og knebøyhopp

På generelt grunnlag anbefales det å benytte pausetider på 1 minutt mellom hoppforsøk ved CMJ og SJ (Petrigna et al., 2019). Av praktiske årsaker ble det benyttet litt kortere pauser i denne undersøkelsen. Ved optimale pausetider kunne kanskje reliabilitet vist seg å være enda bedre. En CV på 3.2% og 3.1% ble målt for hopphøyde ved henholdsvis CMJ og SJ. Dette er noe bedre enn hva Lindberg et al (2022) rapporterte i sin multi testsenter studie. Å benytte det beste hoppet valgt ut fra 2-3 forsøk er vanlig, men kritisert, ettersom gjennomsnittsverdier virker å være mer reliabelt (Claudino et al., 2017). Å benytte hopptester for å måle neuromuskulær fatigue kan benytte flere faktorer, men hopphøyde er lett å måle, samt reliabelt (Claudino et al., 2017; Franceschi et al., 2023). Ettersom deltakerne hadde 3 forsøk under baseline og de nærmeste to ble benyttet, mens bare 2 forsøk under intervensjon er det ikke usannsynlig at CV% ville blitt høyere ved bruk av to forsøk under baseline. Ved svikthopp utførelse var det også ulike dybdevalg mellom deltakerne, men ganske lik innad i hver deltaker. Det kunne vært benyttet en standardisert dybde, som kunne ha ført til enda bedre test retest reliabilitet. Ved SJ ble det oppdaget flere utførelsesfeil enn ved CMJ. I flere tilfeller i starten av intervensjonen utførte deltakerne en liten svikt som førte til at de måtte gjenta hoppet. Likende situasjoner har blitt oppdaget tidligere, og kan vise seg som en svakhet ved SJ (K. A. Lindberg et al., 2022). Det ble utført generell oppvarming og dynamisk tøying før readiness batteriet og knebøyen ble utført, men spesifikk oppvarming for hopp kunne vært inkludert for å prestere best mulig på CMJ og SJ (Pinfold et al., 2018).

2.3.4: Reactive strength index

Ved 10/5 RSI metoden benyttes 11 hopp, ettersom kontakttid i bakken ikke kan inkluderes ved det første hoppet (Harper et al., 2011a). I den originale testprotokollen ble testen utført med flere forsøk, hvor 3 og 5 serier med 11 hopp måtte utføres, og gjennomsnitt RSI scoren ble benyttet (Harper et al., 2011b). Testhoppen godkjennes ved kontakttid med bakken på under .25s (Harper et al., 2011b). I ettertid har reliabiliteten til testen møtt tvil, ettersom CV ble målt til mellom 12.5% og 14.5% (Stratford et al., 2021) i motsetning til 9% ved første undersøkelse (Harper et al., 2011b), som heller ikke er spesielt bra. Fra observasjoner av deltakerne i denne undersøkelsen virker teknikken ved testen å være krevende, ettersom hoppene ofte ble utført med tydelige krefter i både sagital- og frontalplanet, og ikke bare vertikalt. I tillegg var det krevende å holde hendene i hoftefestet. Reliabiliteten i denne undersøkelsen (5.1%) ble målt å være bedre enn nevnte tidligere undersøkelser, til tross for at det bare ble testet èn gang hver testdag. Mulige grunner for dette kan være en god tilvenning eller muskulære forhold.

2.3.5: Isometric mid-thigh pull

For IMTP benyttes oftest en stang, kombinert med et pronert, supinert eller kombinasjonsgrep hvor det holdes rett foran fremside lår. Ettersom det i denne studien ikke benyttes et klassisk grep, men to frie håndtak langs siden av femur kan det diskuteres om målet er like valid. Ved korrekt utførelse av IMTP skal man også ta hensyn til antropometri ved standardisering av vinkler i hofte og kneledd. Dette ble ikke praktisert, med hensikt å spare tid. Slik standardisering ville vært å bruke en mer utprøvd metode (Grgic et al., 2022), og bedre sammenligning mellom ulike forsøkspersoner. For å allikevel holde øvelsen standardisert, ble nøyaktig de samme lengdene på håndtakene benyttet hver gang for alle forsøkspersonene. Peak force, som benyttet i denne undersøkelsen er også blitt ansett å bære god-til-fantastisk test retest reliabilitet i praksis, samt en mulighet for readiness monitorering (Keogh et al., 2020; C. Thomas et al., 2015). Isometrisk knebøy kunne trolig hvert et bedre mål, ettersom overføringsverdien til faktisk knebøy er større (Merrigan et al., 2020). Tabell 6 viser til tilvenningstid ved IMTP. Notabelt er også Baseline 1 til 2 (B1 med B2) hvor kalk ikke ble benyttet.

Tabell 6:

Oversikt over Endringer fra Normen ved IMTP.

Forskjell fra baseline til baseline	**Gjennomsnittlig endring (SD)**	**95% Konfidensintervall**		**Frihetsgrader**	**Tosidig *p*-verdi**
		Nedre grense	Øvre grense		
B1 med B2	-48N (50)	-69.9	-25.5	21	< .001
B2 med B3	-17N (35)	-32.9	-1.8	21	.031
B3 med B4	-7N (28)	-19.7	5.4	21	.252

Mann Whitney-U T-tester

2.4: Dataanalyser

Ved dataanalyser ble det valgt å bruke korrelasjon, flagging ved Z-verdier og multiple regresjon for å undersøke readiness sammen med knebøydata. De ulike prediksjonsvariablene ble derimot aldri koblet systematisk sammen for å vurdere dypere prediksjonsverdi enn regresjonsanalysen og flaggingen. Principle component analysis (PCA) er nylig blitt vurdert til å være hensiktsmessig i flagging av data, spesifikt ved svikthopp (Keogh et al., 2023). Ved en undersøkelse av forskjellige variabler uthentet fra svikthopp, viste dataen å være mer reliabel enn å bruke en variabel for seg selv (som hopphøyde i denne undersøkelsen; Keogh et al., 2023). I liknende grad kunne de beste 3 variablene (Subjektiv, CMJ og MPV) trolig blitt koblet sammen og undersøkt ved PCA. Det betyr ikke nødvendigvis at resultatet ville bydd på mer innsikt enn hva regresjonsanalysen allerede gjorde, men metoden er tiltenkt å by på rask dataflagging, i hvert fall i relasjon til kraftplattform målinger av hopp (Keogh et al., 2023). I likhet med multippel regresjonsanalyse, er heller ikke PCA tilegnet ikke-parametrisk data.

2.4.1: Manglende data og ekskludering av data

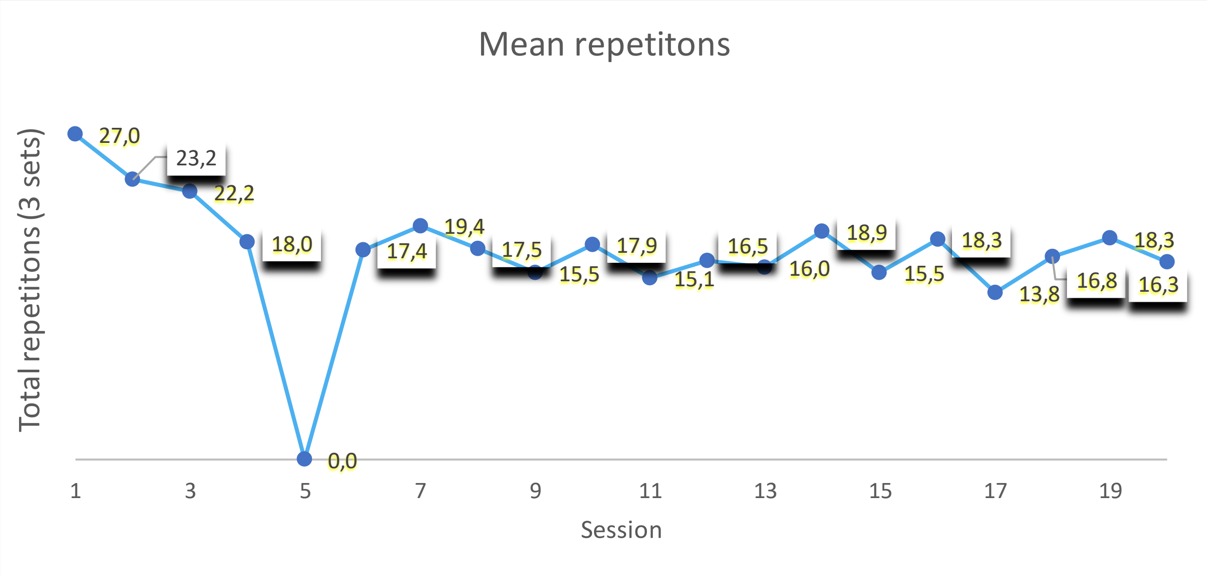
Gode analyser av data står sterkere der det finnes fullverdig data fra de samme deltakerne (Pallant, 2020). Ettersom det var avvik fra økt til økt blant deltakerne, eller deler av readiness-batteriet og knebøytreningen ikke ble utført av hver deltaker hver gang førte dette til manglende data. Siden hensikten med studien krevde knebøydata ved VBT ble øktene som ikke inkluderte 3 serier med knebøy ekskludert fra undersøkelser. Underveis i analysene ble allikevel data fra to økter ekskludert, ettersom det ble oppdaget at deltakeren bare hadde utført to serier knebøy på en av øktene. Dermed måtte begge øktene fra den gjennomsnittlige perioden fjernes.

2.4.2: Knebøydata

Ekskludering av knebøydata de 3 første øktene ble gjort ettersom det ble utført signifikant ($p < .01$) flere repetisjoner (30% VL og 20% VL) helt til økt 4 (Se Figur 3 under). I starten ble det også observert problematikk ved teknikk i form av dybde i løftet og å presse raskt og eksplosivt. Spesifikt at når det begynte å bli ekstra krevende å opprettholde farten, reduserte deltakerne dybden for å kompensere. Eller at deltakeren sa han presset på, men etter hvert hadde nærmest «løst en kode» og klarte å presse gjerne 5-10% raskere ved starten av serien. Begge disse aspektene kan føre til flere repetisjoner. De 3 første øktene ble derfor ansett som tilvenningsøkter for å generalisere for hele gruppen, selv om flere deltakere utførte riktig fra første eller andre økt. Det er også mulig at deltakere som ventet lenger på toppen av løftet enn instruert (4 sekunder eller over) kan ha klart å holde en høyere fart ved de siste repetisjonene ettersom ATP kan produseres ganske raskt, selv med korte pauser (Westerblad et al., 1998). En naturlig feilkilde kan vise til når på dagen utøverne utførte tester og treningen. Utøverne utførte øktene på cirka samme tidspunkt hver gang (U20 kl 08.00 og U18 16.00 – 19.30). Gruppene er derfor gode å sammenligne innad i gruppene, men kan føre til noen forskjeller mellom gruppene. I tillegg kan virkestoffer som koffeininntak påvirke, da spesifikt vist ved hopp og isometrisk beinstyrke (Donahue et al., 2022). For videre innsikt i dataflaggingen, viser Vedlegg 9 rådata fra de flaggede øktene ved repetisjonsvolum.

Figur 3:

Oversiktsbilde av Repetisjons-Volum Deltakerne Utførte per økt. Oddetallsøkter = 80% av 1RM og 30% VLT; Partallsøkter = 70% av 1RM og 20% VLT.



2.4.3: Normalitet

Gjennom Kolomogrov smirnov og Shapiro Wilks normalitetstesting fremstår fluksjonene fra det flytende gjennomsnittet å være ikke-normalfordelt (Se Vedlegg 7). Dersom man har ikke-normalfordelt data anbefales det å benytte ikke-parametriske tester, ettersom de ikke påvirkes i stor grad av de skjevfordelte uteliggerne (J. R. Thomas et al., 2015). Ved store utvalg kan man allikevel vurdere å benytte parametriske tester ettersom skjevfordelingene ikke vil bære like stor innvirkning (Tabachnick & Fidell, 2020). Data undersøkt var endringer fra normen «forventet prestasjon» ved de bevegende gjennomsnittene, som naturligvis har større sannsynlighet for store sprik, versus å benytte faktiske prestasjoner. For eksempel ville en hopp prestasjon på 42cm resultere i datasettet «+2cm» dersom gjennomsnittet var 40cm. Ville samme deltaker hoppe 37.5cm ved neste økt, ville denne dataen representeres som «-2.5cm». Dette gjorde det lettere å inkludere all data i SPSS datasettet, med tydelige endringer fra normen. Det ble valgt å benytte parametriske tester ved alle analyser ettersom regresjonsanalyse ikke har et alternativ ved ikke-normalfordelt data. Det er allikevel verdt å ta i betraktning når man vurderer resultatene at grunnleggende prinsipper for parametriske tester ikke var oppfulgt.

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Liste over vedlegg:

Vedlegg 1: Prosjektets godkjenning av lokaletisk komité

Per Thomas
Byrkjedal

Besøksadresse:
Universitetsveien 25
Kristiansand

Ref: [object Object]
Tidspunkt for godkjenning: 28/02/2020

Søknad om etisk godkjenning av forskningsprosjekt - Hurtighetsbasert styrketrening og en longitudinell oppfølging av belastning i trening og kamp

Vi informerer om at din søknad er ferdig behandlet og godkjent.

Kommentar fra godkjenner:
FEK godkjenner søknaden under forutsetning av at prosjektet gjennomføres som beskrevet i søknaden.

Hilsen
Forskningsetisk komite
Fakultet for helse - og idrettsvitenskap
Universitetet i Agder

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UNIVERSITETET I AGDER
FAKTURAMOTTAK
POSTBOKS 383 ALNABRU 0614 OSLO

Vedlegg 2: Godkjenning fra fra Kunnskapssektorens tjenesteleverandør (SIKT)

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD sin vurdering

Prosjekttittel

Hurtighetsbasert styrketrening og en longitudinell oppfølging av belastning i trening og kamp.

Referansenummer

464080

Registrert

28.01.2020 av Per Thomas Byrkjedal – per.byrkjedal@uia.no

Behandlingsansvarlig institusjon

Universitetet I Agder / Fakultetet for helse- og idrettsvitenskap / Institutt for folkehelse, idrett og ernæring

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Thomas Bjørnsen, thomas.bjornsen@uia.no, tlf: 4798619299

Type prosjekt

Forskerprosjekt

Prosjektperiode

15.02.2020 – 31.12.2023

Status

31.05.2021 – Vurdert

Vurdering (2)

31.05.2021 – Vurdert

Vedlegg 3: Infoskriv og samtykkeskjema for deltakerne

Vil du delta i forskningsprosjektet

eksplosiv styrketrening i sesong for ishockeyspillere?

Dette er en forespørsel til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke effekten av to hastighetsstyrte styrketreningsprogram på fysisk prestasjonsevne hos ishockeyspillere i sesong. I tillegg vil det undersøkes om det finnes sammenheng mellom ens autoregulering og prestasjonen på den hastighetsstyrte styrketreningen I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

Formålet med denne studien er å undersøke effekten av eksplosiv styrketrening på muskelstyrke, power (effekt/eksplosivitet), muskelstørrelse hopp og sprint prestasjon under sesong. Dere blir tilfeldig fordelt til et av to knebøy programmer som er integrert i det eksisterende treningsprogrammet for konkurranseperioden. Det ene knebøyprogrammet vil trene med et standardisert hastighetsfall på 30% i hver serie. Det vil si at man løfter knebøy så raskt man klarer på vei opp, og treningserien stoppes automatisk når skjermen foran dere lyser rødt, som er når hastigheten har sunket med 30% fall fra beste repetisjon. I det andre knebøy-programmet trener man ved å få oppgitt selve løftehastigheten på skjermen, og forsøker å løfte så raskt man klarer på vei opp i alle repetisjoner. En instruktør vil si ifra når man skal avsluttet serien i denne gruppen. Forskning har vist at begge disse programmene hver for seg kan ha god effekt, men ingen studier har sammenlignet de direkte på ishockeyspillere på høyt nivå i sesong. Før treningsprogrammet startes vil dere bli testet for baseline maksimal styrke, eksplosiv styrke og readiness i perioden før sesongstart og er integrert med treningsplanen deres.

Problemstillinger:

- Vil det være forskjell mellom styrketrening med tilbakemelding på 30% hastighetsfall, versus styrketrening med tilbakemelding på hastighet i hver repetisjon, på endring i styrke, sprint, spenst og muskelvekst prestasjon hos ishockeyspillere på høyt nivå i sesong?

- Vil det oppstå en autoregulering ved treningsvolum basert på løftehastighet og readiness i forhold til baseline fra treningsøkt til treningsøkt ved hastighetstyrt styrketrening blant ishockeyspillere på høyt nivå i sesong?

Hvem er ansvarlig for forskningsprosjektet?

Universitetet i Agder (UiA) er ansvarlig for prosjektet. Prosjektansvarlig er Førsteamanuensis Thomas Bjørnsen (kontaktinformasjon nedenfor).

Hvorfor får du spørsmål om å delta?

Du blir spurt om å delta i prosjektet da du treffer målgruppen som er mannlige ishockeyspillere på høyt nivå i alderen 16-20 år med god helse.

Hva innebærer det for deg å delta?

For å delta krever det at hver deltaker oppgir navn, fødselsår og kontaktinfo. Videre innebærer deltakelse at hver person gjennomfører fysiske tester ved klubbens treningslokaler i Stavanger og ved Olympiatoppen Sørvest (Vikinghallen). Etter første testrunde blir man randomisert (tilfeldig fordelt) i en av to knebøy-program som trenes i 10 uker under kampsesong. Tidspunkt for testing og trening er planlagt for høsten 2023.

For å kunne delta er det ønskelig at hver deltaker:

- Gjennomfører fysiske tester før og etter treningsperioden fordelt på totalt 2 dager
    - Tester tar 2-4 timer per oppmøte
    - Testene må gjennomføres i utvilt tilstand før og etter treningsperioden. Uthvilt tilstand betyr uten å ha gjennomført hard anstrengende trening de siste 48 timene og unngå all *uvant* trening de siste 72 timene.
- Gjennomfører knebøy-programmet som er blitt utdelt under hele treningsperioden. Det planlegges 2 knebøyøkter per uke med cirka 4 serier per økt.

Testene som utføres før treningsperioden og underveis i treningsperioden

Før oppstarten av treningsperioden vil du utføre baseline-testinger for svikthopp, squatjump, kontinuerlige svikthopp (RSI), en isometrisk/statisk beinøvelse og subjektiv restitusjon fra 1 –

10. Baseline testing vil skje mellom 2 – 8 økter i ukene før treningsperiodens start/sesongstart 19. september.

I starten av hver økt vil du, utføre 2 svikthopp, 2 squatjumps, 11 kontinuerlige hopp (RSI) og en isometrisk/statisk beinøvelse på Alphatek sin kraftplattform, samt gi din subjektive opplevelse av restitusjon (1 – 10).

Testene som utføres både før og etter treningsperioden:

- Høyde og vekt
- Muskelstørrelse av samme lårmuskulatur med ultralyd.
- En kroppsscan (Inbody) som måler din totale muskelmasse i kroppen.

Deretter er det en 10 minutters lang oppvarming etterfulgt av 3 forsøk for hver test og med 3 minutter pause mellom hvert forsøk:

- 30 meter sprint (med splittider) av og på is.
- Svikthopp og knebøyhopp.
- Styrke og power (effekt/eksplosivitet) tester i bein.

Treningsgruppene

Selve treningsprogrammet og antall serier i knebøy utarbeides sammen med fysisk trener Dennis Sveum, imens måten knebøyseriene blir justert på i begge grupper er utarbeidet i fra tidligere forskning på lagspillutøvere for å maksimere eksplosiv prestasjon.

Deltakerne vil bli tilfeldig delt inn i to treningsgrupper. Knebøytreningen i den ene gruppa vil bestå av to økter i uken hvor hver serie stoppes ved et hastighetsfall på 30% som kommer opp på skjermen rett foran knebøystativet. Den andre gruppen vil trene de samme to øktene med knebøy samtidig som man får oppgitt selve løftehastigheten på skjermen. En instruktør vil si ifra når man skal avsluttet serien i denne gruppen. I begge gruppene forsøker man å løfte så raskt man klarer på vei opp i alle repetisjoner.

Begge gruppene vil trene sentrale muskelgrupper ~2 ganger per uke under hele prosjektperioden utarbeidet sammen med fysisk trener, ved siden av lagtreninger og kamper.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Kun forskningsleder og masterstudenter har tilgang til koblingen mellom måleresultatene og dine personopplysninger. Opplysningene vil anonymiseres når prosjektet avsluttes/oppgaven er godkjent, noe som etter planen er 31.12.2025. Det vil ikke være mulig å identifisere deg ut fra måleresultatene etter opplysningene er blitt anonymisert.

Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?

Prosjektet vil etter planen avsluttes 31.12.25 og da vil kodelisten destrueres, noe som betyr at innsamlet informasjonen er anonymisert og ingen opplysninger kan spores tilbake til deg.

Anonymiserte resultater vil bli sendt inn til fagfellevurderte forskningsjournaler i etterkant og er en del av masteroppgaver ved Universitetet i Stavanger. Anonymisert innsamlede data vil bli slettet fem år etter prosjektslutt, eller når resultatene er publisert. Alle testresultater vil bli behandlet uten navn og fødselsnummer eller andre direkte persongjenkjennende opplysninger. En kode knytter deg til dine opplysninger og testresultater gjennom en navneliste. Det er kun prosjektleder og masterstudenter som har adgang til navnelisten og som kan finne tilbake til deg. Det vil ikke være mulig å identifisere deg i resultatene av studien når disse publiseres. Deltakerne kan også bli kontaktet på et senere tidspunkt dersom det skulle bli aktuelt med oppfølgingsstudier. De kan velge å takke nei selv om de er med i treningsintervensjonen.

Hva gir oss rett til å behandle personopplysninger om deg? Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Universitetet i Agder (UiA) har Personverntjenester (Norsk senter for forskningsdata) vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke opplysninger vi behandler om deg, og å få utlevert en kopi av opplysningene
- å få rettet opplysninger om deg som er feil eller misvisende
- å få slettet personopplysninger om deg
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger

Hvis du har spørsmål til studien, eller ønsker å vite mer om eller benytte deg av dine rettigheter, ta kontakt med:

- Masterstudent Vegard Ege Bjelland, epost: ve.bjelland@stud.uis.no, tlf: 414 93 887
- Masterstudent Henrik Vormeland Paulsen, epost: hv.paulsen@stud.uis.no, tlf: 995 78 519
- Prosjektmedarbeider og Førsteamanuensis Håvard Myklebust, epost: havard.myklebust@uis.no, tlf: 994 12 463
- Prosjektansvarlig og Førsteamanuensis Thomas Bjørnsen, epost: thomas.bjornsen@uia.no, tlf: 986 19 299

- Kontakt vårt personvernombud ved Universitetet i Agder:
  - Rådgiver Trond Hauso (trond.hauso@uia.no, 936 01 625)

Spørsmål knyttet til Personverntjenester sin vurdering av prosjektet, kan du ta kontakt med:

- Personverntjenester på epost (personverntjenester@sikt.no) eller på telefon: 53 21 15 00.

Med vennlig hilsen

Vegard E. Bjelland (Masterstudent)

Henrik V. Paulsen (Masterstudent)

Dennis Sveum (Fysisk trener Oilers)

Håvard Myklebust (Veileder/Førsteamanuensis)

Thomas Bjørnsen (Prosjektleder/Veileder/Førsteamanuensis)

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet styrketrening i sesong for mannlige hockeyspillere, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å gjennomføre alle fysiske prestasjonstester (styrke, power, sprint, hopp)
- ☐ å gjennomføre målinger av muskelstørrelse (ultralyd) og kroppssammensetning (Inbody)
- ☐ å gjennomføre spørreskjemaer underveis i studien
- ☐ Å gjennomføre knebøy-programmet man blir trukket til å gjøre

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

----

(Signert av prosjektdeltaker, dato)

Vedlegg 4: Author Guidlines

Sections

1. SUBMISSION

Thank you for considering *Scandinavian Journal of Medicine & Science in Sports* for the publication of your research.

Due to the large number of inquires we are currently receiving, we will no longer offer comments on the suitability of a paper prior to submission. If you believe your paper to be within scope of the journal, we encourage you to submit so our editors can easily review your submission and follow up with you directly if needed.

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Following our initial check, all manuscripts are screened by the Editorial Board for suitability for publication; to ensure that they meet essential criteria for sending out to peer review and, subsequently, to be read and cited and, thereby, make a contribution.

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- An ORCID ID, freely available at https://orcid.org. (*Why is this important? Your article, if accepted and published, will be attached to your ORCID profile. Institutions and funders are increasingly requiring authors to have ORCID IDs.*)
- The title page of the manuscript, including:
  - Your co-author details, including affiliation and email address. (*Why is this important? We need to keep all co-authors informed of the outcome of the peer review process.*)
  - Statements relating to our ethics and integrity policies, which may include any of the following (*Why are these important? We need to uphold rigorous ethical standards for the research we consider for publication*):
    - data availability statement
    - funding statement
    - conflict of interest disclosure
    - ethics approval statement
    - patient consent statement
    - permission to reproduce material from other sources
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2. AIMS AND SCOPE

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It aims to publish high quality and impactful articles in the fields of orthopaedics, rehabilitation and sports medicine, exercise physiology and biochemistry, biomechanics and motor control, health and disease relating to sport, exercise and physical activity, as well as on the social and behavioural aspects of sport and exercise.

3. MANUSCRIPT CATEGORIES AND REQUIREMENTS

i. Original Article

Word limit: **Page charges will apply to articles exceeding 8 pages**. Please see the Publication Process after Acceptance section.

Abstract: 250 words maximum.

Keywords: Please provide 3-8 keywords.

References: Maximum of 40 references.

Figures/Tables: A total of 8 figures and/or tables is allowed.

Main text structure: Introduction; Materials and Methods (including statement that informed consent and local ethics committee approval has been provided for human studies); Results; Discussion; Perspective.

Perspective: It is mandatory that all manuscripts include a brief perspective paragraph at the end of the discussion in which the findings are put into perspective in the relevant area of sports medicine. This includes reference to possible previous articles in this and other journals and the potential impact of the present findings. This paragraph should not exceed 200 words.

ii. Review

Abstract: 250 words maximum.

Keywords: Please provide 3-8 keywords.

References: Maximum of 120 references.

Figures/Tables: Authors are encouraged to keep the number of figures and tables to a minimum.

Perspective: It is mandatory that all manuscripts include a brief perspective paragraph at the end of the discussion in which the findings are put into perspective in the relevant area of sports medicine. This includes reference to possible previous articles in this and other journals and the potential impact of the present findings. This paragraph should not exceed 200 words.

iii. Letter to the Editor

Letters to the editor should pertain to crucial scientific aspects, such as the interpretation of data or methods related to a recent article in the journal, including reviews and opinion articles. The content must remain focused on scientific aspects, avoiding any derogatory language. The authors of the referenced article will be able to respond, and their response will be published. Letters should not introduce new data, although such data can be presented in the response. If any original article author chooses not to participate in the response, this should be mentioned as a note at the end of the rebuttal letter. The letter to the editor may also present a short opinion piece or address a controversial issue of recent relevance in Sports Sciences or Sports Medicine or submit a comment on a single case study.

Letters to the editor should be at most 600 words and may include either 1 Figure or 1 Table of a reasonable size. The maximum number of references that can be included in the letters to the editor is 10. Upon submission, a member of the Editorial Board will review the Letter to determine its suitability for publication and may decide to invite reviewers if deemed necessary. Decisions to not publish a Letter may be made by an Editor if the Letter lacks scientific merit or if the topic is deemed irrelevant to the readers of the journal. If accepted, an invitation for a reply will be extended to the authors of the article commented on in the Letter. If the authors refuse to write a rebuttal letter or it is not submitted within a month after the invitation, SJMSS retains the right to publish it even without a Reply.

iv. Consensus Statement

Announcement of consensus statements or meeting reviews and other topics of interest can be submitted.

4. PREPARING THE SUBMISSION

Cover Letters

Cover letters are not mandatory; however, they may be supplied at the author's discretion.

Parts of the Manuscript

The manuscript should be submitted in separate files: main text file; figures.

Main Text File

Manuscripts can be uploaded either as a single document (containing the main text, tables and figures), or with figures and tables provided as separate files. Should your manuscript reach revision stage, figures and tables must be provided as separate files. The main manuscript file can be submitted in Microsoft Word (.doc or .docx) or LaTex (.tex) format.

If submitting your manuscript file in LaTex format via Research Exchange, select the file designation "Main Document – LaTeX .tex File" on upload. When submitting a Latex Main Document, you must also provide a PDF version of the manuscript for Peer Review. Please upload this file as "Main Document - LaTeX PDF." All supporting files that are referred to in the Latex Main Document should be uploaded as a "LaTeX Supplementary File."

Your main document file should include:

- The appropriate Section Specialty Area for your paper should be indicated at the top of your main manuscript file or in your title page. Please select the appropriate Section Specialty Area from this list
- A short informative title containing the major key words. The title should not contain abbreviations
- The full names of the authors with institutional affiliations where the work was conducted, with a footnote for the author's present address if different from where the work was conducted;
- Acknowledgments;
- Up to eight keywords;
- Main body: formatted as introduction, materials and methods, results, discussion, acknowledgements, conflict of interest statement;
- References;

- Tables (each table complete with title and footnotes);
- Figures: Figure legends must be added beneath each individual image during upload AND as a complete list in the text.

Best Practices for Manuscript Transformation

- The main manuscript file must be submitted in Microsoft Word (.doc or .docx) or LaTex (.tex) formats.
- Figures should be numbered in the order that they are cited in the text, and presented in that order after the text of the paper
- Full names (First, Middle, and Last) should be provided for all authors
- Authors should include the complete affiliation addresses in the manuscript. At minimum, authors should include the institution name and country, but a complete affiliation also includes department name and institution city. The institution postal code is optional.

Authorship

Please refer to the journal's authorship policy the Editorial Policies and Ethical Considerations section for details on eligibility for author listing.

Acknowledgments

Contributions from anyone who does not meet the criteria for authorship should be listed, with permission from the contributor, in an Acknowledgments section. Financial and material support should also be mentioned. Thanks to anonymous reviewers are not appropriate.

Conflict of Interest Statement

Authors will be asked to provide a conflict of interest statement during the submission process. For details on what to include in this section, see the section 'Conflict of Interest' in the Editorial Policies and Ethical Considerations section below. Submitting authors should ensure they liaise with all co-authors to confirm agreement with the final statement.

Keywords

Please provide a maximum of 8 keywords.

References

All references should be numbered consecutively in order of appearance and should be as complete as possible. In text citations should cite references in consecutive order using Arabic superscript numerals. For more information about AMA reference style please consult the AMA Manual of Style

Sample references follow:

Journal article

1. King VM, Armstrong DM, Apps R, Trott JR. Numerical aspects of pontine, lateral reticular, and inferior olivary projections to two paravermal cortical zones of the cat cerebellum. J Comp Neurol 1998;390:537-551.

Book

2. Voet D, Voet JG. Biochemistry. New York: John Wiley & Sons; 1990. 1223 p.

Internet document

3. American Cancer Society. Cancer Facts & Figures 2003. http://www.cancer.org/downloads/STT/CAFF2003PWSecured.pdf Accessed March 3, 2003

Tables

Tables should be self-contained and complement, not duplicate, information contained in the text. They should be supplied as editable files, not pasted as images. Legends should be concise but comprehensive – the table, legend, and footnotes must be understandable without reference to the text. All abbreviations must be defined in footnotes. Footnote symbols: †, ‡, §, ¶, should be used (in that order) and *, **, *** should be reserved for P-values. Statistical measures such as SD or SEM should be identified in the headings.

Figure Legends

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Author Guidelines Updated 15 February 2021

Vedlegg 5: Treningsplanen

Tabell 1:

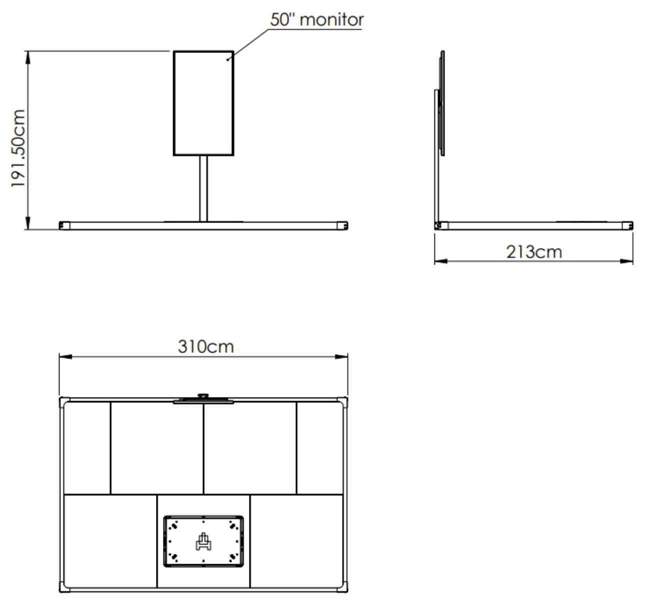
Oversikt Treningsplanen i sin Helhet Gjennom Intervensjonen.

	Weekly session 1		**Weekly session 2**	
	Exercise	**Sets x Repetitions**	**Exercise**	**Sets x Repetitions**
Week 1 - 5	BBsq 80% 1RM	3 x 30% VL	BBsq 70% 1RM	3 x 20% VL
	B1. Barbell alternating step ups	3 x 10 (5el)	B1. Barbell bench press	4 x 6
	B2. Lateral step up jumps	3 x 3el	B2. Line quick feet; forward backward jump both legs	2 x 7 sec
	C1. Swissball hamstring curl	3 x 15	B3. Line quick feet; forward backward jump one-leg	2 x 7 sec
	C2. Landmine Cossack mobility	3 x 10 (5el)	C1. Pullups (Weighted)	3 x maximum
	C3. Copenhagen plank (partner hold)	3 x 10ea	C2. Line quick feet; lateral jumps both legs	2 x 7 sec
	C4. Landmine rotation (explosive)	3 x 12 (6el)	C3. Line quick feet; lateral jumps one-legged	2 x 7 sec
			D1. Band clean + press	3 x 10
			D2. Bent over reverse flies	3 x 12
			D3. Line quick feet; forward backward sprint	2 x 7 sec
			D4. Line quick feet; in & out jump	2 x 7 sec

	Weekly session 1		Weekly session 2	
	Exercise	**Sets x Repetitions**	**Exercise**	**Sets x Repetitions**
Week 6 - 10	A1. BBsq 80% 1RM + 2.5kg (+5kg week 9-10)	3 x 30% VL	A1. BBsq 70% of 1RM + 2.5kg (+5kg uke 9-10)	3 x 20% VL
	B1. Deficit reverse lunge	3 x 8 el	B1. Bench press	4, 4, 3, 2
	B2. Band assisted vertical jump	3 x 3	B2. Suitcase KB march	3 x 10 + 10
	B3. Depth broad jump	3 x 3	C1. Single arm landmine row	3 x 10
	C1. Single leg small hurdle hoops	3 x 3 el	C2. Kneeling biceps curl	3 x 12
	C2. Single leg Romanian deadlift	3 x 10 el	C3. Weighted deadbug	3 x 20
	C3. Calf raise farmers walk	3 x 20 (10 el)		

BBsq = Barbell back squat., **el =** each leg.,**ea** = each arm **X1,X2,X3,X4** = Sets performed as a super/giant set back to back without rest., **VL** = Velocity Loss., **+2.5/5kg** = added load from initial 1RM

Vedlegg 6: Alphatek plattformoppsett, mål og spesifikasjoner



Alphatek

Product specification sheet

AlphaPWR medium

Technical Requirements:

Electrical:
- Input Voltage: 2x AC 100-240 V (50/60 Hz)
- Maximum Power Consumption: 300W

Physical Requirements:
- Surface: Level surface with hard floor (Rubber tiles are acceptable)
- Recommended Roof Height: 275cm
- Dimensions: Refer to the drawing on the left for detailed physical dimensions

Internet Requirements:
- Connection: 2x Ethernet connection (CAT5); Wifi is not supported

Environmental Conditions:
- Operating Temperature: 32 °F – 104 °F (0 °C – 40 °C)
- Humidity: 10% – 80%, non-condensing

Vedlegg 7: Normalitetstesting av datasettet (prestasjon minus norm)

		Kolmogrov-Smirnov		Shapiro-Wilk	
Variabel	**n**	**Statistikk**	**p-verdi**	**Statistikk**	**p-verdi**
Subjektiv	364	.079	<.001	.988	.004
CMJ	371	.054	.012	.99	.015
SJ	370	.044	.087	.992	.042
RSI	356	.077	<.001	.954	<.001
IMTP	165	.114	<.001	.944	<.001
MPV	371	.07	<.001	.990	.010
Reps	371	.057	.006	.988	.005

Vedlegg 8: Norsk oversatt versjon for restitusjon (subjektiv readiness skala)

Hvor restituert og uthvilt er du?

Vurder ut ifra skalaen under

10	**Helt restituert og uthvilt**	
	Svært energisk/toppform	**Forventer å**
9		**prestere godt**
8	**Godt restituert og uthvilt**	
	Ganske energisk	
7		
6	**Over middels restituert og uthvilt**	**Forventer å**
5	**Tilstrekkelig restituert og uthvilt**	**prestere på det**
4	**Delvis restituert og utvilt**	**jevne**
3		
2	**Ikke særlig restituert**	
	Ganske sliten	**Forventer å**
1		**prestere under**
0	**Veldig lite restituert**	**middels**
	Svært sliten	

Laurent et al. 2011: A practical approach to monitoring recovery: development of a perceived recovery status scale

Vedlegg 9: Flagget repetisjonsvolum

Eksempelet under gir innsikt i hvordan sammenhenger mellom dataflagging ble gjort, illustrert med flagget repetisjonsvolum data. Den mørkegrønne fargen tilsvarer en økning fra normen på 1.65 Z-score eller mer. Rød farge en nedgang fra normen med 1.65 Z-score eller mer. Lysegrønn viser til en oppgang fra normen på mellom 1Z-score, men under 1.65 Z-score. Gul viser til en nedgang fra normen på mellom 1Z-score, men under 1.65 Z-score. Ingen farge viser at prestasjonen var 1Z-score > -1Z-Score. Tallverdiene ved alle kolonner er faktisk prestasjon og fargen over forteller om endring fra norm. Øverst i kolonnen står det hvilken variabel som er målt og hver rekke representerer et individ gjennom en økt. Reps total er antall repetisjoner utført på den hastighetsstyrte knebøyen, mens Gj.s er antall repetisjoner som tilsvarte individets sin norm. Gjennomsnittsdata er ikke vist ved 30% hastighetstaps-terskel.

Oversikt over flagget repetisjons-volum under 20% hastighetstaps-terskel

Subjektiv	CMJ_mean	SJ_mean	5/10 RSI	IMTP	MPV	Reps total	Gj.s
6	35,8	32,9	1,64	312	0,62	29	23,3
6	34,15	33,7	1,92	226	0,58	25	20,5
4	44,7	42,3	1,36	264	0,50	25	21,0
3	42	41,5	1,75		0,58	12	9,7
3	39,2	37,9	1,65		0,61	28	23,3
5	45,7	43,15	1,68	216	0,65	26	21,7
6	39,7	37,5	1,43	378	0,58	18	15,0
7	45,4	42,8	1,82	279	0,64	26	20,5
5	41,45	41,85	1,65		0,635	22	18,0
4	42,35	44,35	1,31		0,51	22	18,0
6	54,7	50,85	1,26	219	0,536667	17	13,5
6	42,85	43,3	1,86	267	0,52	11	14,0
5	33,1	31,65	1,54	261	0,45	9	12,0
	46,2	42,6	1,48		0,51	17	21,0
8	41,55	42,15	1,88		0,57	15	18,7
5	44,65	45,05	2,12	278	0,636667	15	20,5
7	54,3	49,75	1,38		0,51	10	13,5
6	45,85	44,35	1,62		0,603333	16	20,7
6	48,7	50,15	2,13	284	0,58	12	15,0
7	41,85	40,55	1,69	318	0,65	22	18,7
6	33,05	33,05	1,64	262	0,47	14	12,0
5	38,4	36,85	1,36	272	0,54	21	18,0
7	44,5	45,35	2,31	259	0,63	26	22,5
7	42,15	43,7	1,92		0,53	16	14,0
5	40,3	37,35	1,74	183	0,543333	17	15
4	40	39,85	2,01	299	0,553333	18	15
6	48,5	48,85	2,13		0,543333	17	15,0
5	43	41	1,59		0,596667	24	20,7

Subjektiv	CMJ_mean	SJ_mean	5/10 RSI	IMTP	MPV	Reps total	Gj.s
5	39,1	35,85	1,64		0,543333	24	21,0
7	47,6	47,45	2,15		0,613333	27	24,0
5	35,15	34,85	1,96	238	0,56	20	18,0
3	43,5	40	1,47	275	0,58	23	20,7
5	38,45	36,55	1,93	225	0,54	20	23,3
5	46,4	46,9	1,85	252	0,65	20	22,7
5	46,2	45	2,07	216	0,64	19	21,7
5	37,05	35,3	1,93	235	0,54	18	20,5
	35,3	32,65	1,60		0,62	20	23,3
7	37,8	37,35	1,52		0,65	13	15,0
6	38,9	38,7	1,55		0,45	10	11,7
5	40,65	39,35	1,47	228	0,61	16	18,3
4	38,9	39,05	1,64	222	0,55	17	19,8
5	40,7	38,6	1,68		0,57	8	9,7
6	39,05	39,1	1,70	214	0,543333	13	15
4	37,95	38,9	2,29	316	0,523333	12	15
6	43,35	39,1	1,43		0,573333	18	20,7
4	46,4	46,75	2,09		0,633333	21	24,0
6	34,25	34,7	1,57		0,496667	16	18,0
6	42,15	38,9	1,63		0,573333	15	18,0
4	41,8	45	1,79		0,476667	16	18,0
5	35,45	33,6	1,34	302	0,486667	18	21,0
6	45,7	42,65			0,506667	16	18,0

Oversikt over flagget repetisjons-volum under 30% hastighetstaps-terskel

Subjektiv	CMJ	SJ	RSI	IMTP	MPV	Reps total
5	30	29,5	1,73		0,30	6
5	38,3	37,65	1,80		0,40	11
6	34,4	32,55	1,62	300	0,49	7
7	31,8	30,5	1,78	254	0,34	12
4	38,45	38,6	1,59		0,45	19
5	39,5	34,25	1,84		0,48	19
7	48,1	49,05	M		0,53	31
5	38,9	37,05	1,77	292	0,46	13
6	45,35	45	1,94	344	0,52	20
5	48,9	47,4	1,62		0,50	12
6	43,3	41,5	1,72		0,44	11
5	37,85	38,7	1,65		0,500	18
5	38,3	37,8	1,840		0,500	15
5	38,25	36,55	1,86		0,383	12
4	32,65	34,1	1,35		0,3567	14
7	45,5	44,15	1,96		0,583	14
7	29,65	29,35	1,67		0,20	8
5	43,15	44,35	2,01		0,48	9
4	49,50	48,65	2,28		0,48	20
5	45,40	42,7	2,12		0,49	13
5	39,85	40,85	2,490		0,42	15
6	40,2	37,95	1,64		0,473	28
6	38,6	38,9	1,70	190	0,533	24
8	38,75	37,5	1,60		0,403	19
8	40,05	39,25	1,52	261	0,397	19
6	44	43,15	2,03	228	0,483	21
7	29,5	28,15	1,450	245	0,33	11
5	42,5	44,2	1,62	304	0,50	13
5	42,3	38,8	1,76	337	0,47	18
5	41,65	40,5	2,58		0,44	20
6	48,65	45,2	2,12		0,49	15
5	40,55	37,75	2,17		0,46	19
6	39,55	36,4	1,50		0,39	19
6	50,6	48,7	1,72		0,47	16
6	43,5	40,5	1,92		0,45	15