Playing position influences ankle proprioception and evertor strength in professional soccer players

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Background: Data on ankle proprioception and evertor muscle function in professional soccer players remain limited.

Purpose: The goal of this study was to describe the main parameters of lateral ankle stability in the members of a first division professional football team using a specific ankle proprioceptive rehabilitation device. We also explored whether playing position, age, and professional experience were associated with these parameters.

Methods: Thirty-two professional male first-division soccer players were considered for inclusion. The subjects underwent a battery of tests and a retrospective analysis of prospectively collected data was conducted. All measurements were performed by the same examiner who was trained in the use of the specific ankle proprioceptive rehabilitation device: three for proprioception (repositioning, dissociation and functional) and three for muscular reinforcement (eccentric, concentric and functional).

Results: Thirty-two players were included. Mean normalized scores (0–100%) were 59.5 ± 23.7 for ankle repositioning proprioception and 61.3 ± 29.5 for concentric evertor strength. The foot used (non-kicking vs kicking) did not influence the results of the proprioceptive assessment or muscle strength. Mid-fielders ($p < 0.01$), goalkeepers ($p=0.03$) and players with a history of ankle injury in the non-kicking foot ($p < 0.01$) had the best repositioning proprioception results. Goalkeepers had the best dissociation proprioception results ($p < 0.01$). Concentric muscle strength values increased with age ($p < 0.01$), the number of years as a professional player ($p<0.01$), and an absence of a history of knee injury in the non-kicking leg ($p=0.02$).

Conclusion: Ankle proprioception was significantly associated with playing position. Goalkeepers, and to a lesser extent mid-fielders have the best proprioception scores. Age and experience as a high-level professional player are associated with better concentric recruitment of evertor muscles.

What is known about the subject: The main factors to prevent ankle ligament injuries are: 1/ proprioception; 2/ strengthening the ankle inverter muscles; and 3/ pre-activating these muscles. This rehabilitation work is generally done regardless of the position occupied by the player, without individualizing the training.

What this study adds to existing knowledge: This is the first study to investigate the properties of proprioception and strength of the eversion muscles among players of a first division soccer team, and to compare these data according to the position occupied.

Study design: Cross-sectional observational study

Level of evidence: IV

Keywords: Soccer; Proprioception; Kinematic; Ankle sprain risk factor; Prevention

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Introduction

Lateral ankle sprains (LAS) are one of the most frequent sport's injuries with an incidence of 2.15 pour 1000 person years in the United States [1]. Soccer is a high risk sport [2][3][4][5]. The LAS represent the third most frequent injury in first division professional soccer players, and approximately 16.7% of all injuries per season and and may lead to recurrent instability, time loss, and reduced performance [6].

LAS affect passive ankle stability by injuring structures of the ankle capsule and ligaments as well as by creating local neuromuscular changes [7], which are rapidly associated with cortical disorganization [8]. Prevention of these LAS and early management is essential for professional players [9][4][10].

Neuromuscular rehabilitation is one way to prevent injury to the ligaments of the ankle. It is effective for: 1/ proprioception; 2/ strengthening the evertor muscles of the ankle; and 3/ pre-activation of these muscles [11][12][13][14][15][7][16][10][17][18]. Until now deficits in proprioception and muscular strength have been evaluated by isokinetic tests and/or electromyogram (EMG). However, the use of these techniques has been limited by the difficulty of performing the tests in the clinical setting [18]. Several recent studies have confirmed the value of using a specific destabilization device inspired by the functional anatomy of the hind foot, which creates destabilization around Henke's axis [12][13][14][15][7][10]. Quantitative data on proprioceptive and muscular function can be obtained with this type of device, and targeted rehabilitation can be improved.

Prevention and rehabilitation strategies rely mainly on proprioceptive training and evertor muscle strengthening; however, objective data describing these neuromuscular parameters in elite professional soccer players remain limited. In professional teams, such information could support screening and individualized prevention programs. Importantly, playing position may matter because soccer positions involve different movement patterns and exposure: goalkeepers perform frequent landing and cutting maneuvers with unilateral weight shifts, while midfielders are repeatedly exposed to rapid changes of direction, duels, and high running volume. These position-specific demands may influence ankle neuromuscular control and could translate into different proprioceptive or strength profiles.

To our knowledge there are no studies in the literature evaluating proprioceptive and muscular function of the evertor muscles in professional athletes, in particular soccer players.

The goal of this study was to describe the main parameters of lateral ankle stability in the players of a first division professional soccer team. The secondary goal was to search for factors influencing these parameters. We hypothesized that ankle proprioceptive performance and evertor muscle function may differ according to playing position, reflecting position-specific biomechanical demands and training exposures in professional soccer.

Materials and methods

Patients

All members of a first division French men's soccer team during the season of 2020 were identified and eligible for inclusion. The study received ethical approval/registration (ID-RCB: 2020-A00338-31), and written informed consent was obtained from all participants.

A retrospective analysis of prospectively collected data was performed. Inclusion and exclusion criteria are presented in **Table 1**. The following information was obtained for each subject: age, Body Mass Index (BMI), number of years as a professional player, playing position (offense, mid-field, defense, goalkeeper). The following medical data were obtained at the time of the test: history of ankle or knee injury (sprain/ligament injury, fracture, dislocation, or surgery), and which side (on the kicking or non-kicking leg). Leg dominance was defined as the preferred leg used to kick a ball.

All these data were recorded by a neutral examiner (blinded for review) who was not involved in the measurement or interpretation of the results.

Study protocol

Both ankles were evaluated in all subjects. All measurements were performed with the specific ankle destabilization device (Myolux e-volutionTM, ICC Physio, France) which has been previously described [14][15].

This device is a dedicated ankle destabilization system designed to assess proprioceptive control and evertor muscle performance during controlled inversion–eversion tasks of the hindfoot. The platform induces alternating inversion–eversion movements around the subtalar functional physiological Henke axis while the participant maintains balance and performs standardized tasks displayed on the interface. The Henke axis refers to the functional subtalar joint axis, which is obliquely oriented and characterizes the triplanar coupled motion of the subtalar joint during inversion–eversion.

The subject's foot was placed in the shoe device and examined, with a single leg stance and the articulator placed under the hind foot (**Figure 1**).

Table 1. List of study inclusion and exclusion criteria

Inclusion criteria	Player is a member of a 1st division men's team
	Over 18 years old
Exclusion criteria	Inury or sprain to the knee or ankle in the last 3 months
	History of surgery to the ankle ligaments (ligament reconstruction, ligament tightening)

Figure 1. The ankle destabilization device used for proprioception and evertor muscle assessment (participant position and hindfoot platform).

The device was equipped with an inclinometer and a gyroscopic sensor (Shimmer3, Wireless Sensor Platform, Dublin, Ireland) to obtain signals of angular displacement, and of speed associated with inversion. All data were recorded in real-time with a specific application on an electronic tablet (**Figure 1**).

Measurement protocol

All measurements were performed by the same examiner, who was trained to use the specific ankle destabilization device and blind to medical and professional data as well as to the preferred side of the players. Each session lasted 30 minutes, and included 6 exercises: three for proprioception (repositioning, dissociation, and functional) and three for muscular reinforcement (eccentric, concentric and functional). The principles of each test are summarized in **Table 2**, and the exercise interface in **Figure 2**. Each exercise lasted 5 minutes: one minute to present the exercise to the subject, 2 minutes of training to understand the test, one minute to rest, then one minute for the final test. The minute of rest limited the potential effects of muscular fatigue on the results. All outcomes were reported as normalized performance scores (0–100%), with higher values indicating better performance and 100% representing the best achievable score on the device.

Statistical analysis

Means and standard variations were used to describe continuous variables. The number of events and percentages was used to describe dichotomous variables. A Wilcoxon test was used to compare continuous variables. Linear regression was performed to determine if the identified variables could influence the main parameters of lateral ankle stability. The results are presented with the beta coefficients, and their 95% confidence intervals. $P \geq 0.05$ was considered to be significant for a power of 80% and an alpha risk of 5%. R 3.5.0 software was used to perform the statistical analyses.

Table 2. Explanation of the principle of proprioception and muscular reinforcement tests

Proprioception	Repositioning (10 series)	1/ Place the orange point in the green area 2/ Stay still for 1 second to confirm the position then repeat (« target position ») 3/ Return to the original position 4/ Return to the target position with your eyes closed and maintain for 2 seconds 5/ The total score is reduced by 5% for every error between 2-4°, 10% for errors of more than 4°
	Dissociation (10 series)	1/ Keep the forefoot flat on the ground for the entire exercise 2/ Go back and forth with the orange point between the green targets 3/ The total score is reduced by 5% for each incorrect position
	Functional (20 seconds)	1/ A straight knee, with the hindfoot on the articulator and the forefoot on an unstable platform 2/ Keep the orange point in the (green) target area 3/ The total score is reduced by 5% for every second outside of the target area
Muscle Strengthening	Eccentric (20 series)	1/ Straight knee, with the forefoot off the ground and the articulator on a 2.5cm platform 2/ Go from the high position to the low position moving the orange point as slowly and smoothly as possible (uncontrolled movements are penalized) 3/ The orange point should not go slower than the tolerated speed (60m/s) 4/ The total score is reduced by 5% for every incorrect position
	Concentric (60 seconds)	1/ Straight knee, with the forefoot off the ground and the articulator on a 2.5cm platform 2/ Go from the low position to the high position so the orange point is above the threshold value (300 m/s) 3/ 5% is added to the total score each time the point goes above the threshold value
	Functional (20 seconds)	1/ Straight knee, with the forefoot off the ground and the articulator on a 2.5cm platform 2/ Make sure that the orange point is always in the (green) target areas as they randomly appear 3/ The total score is reduced by 5% for every second the point is outside the target area

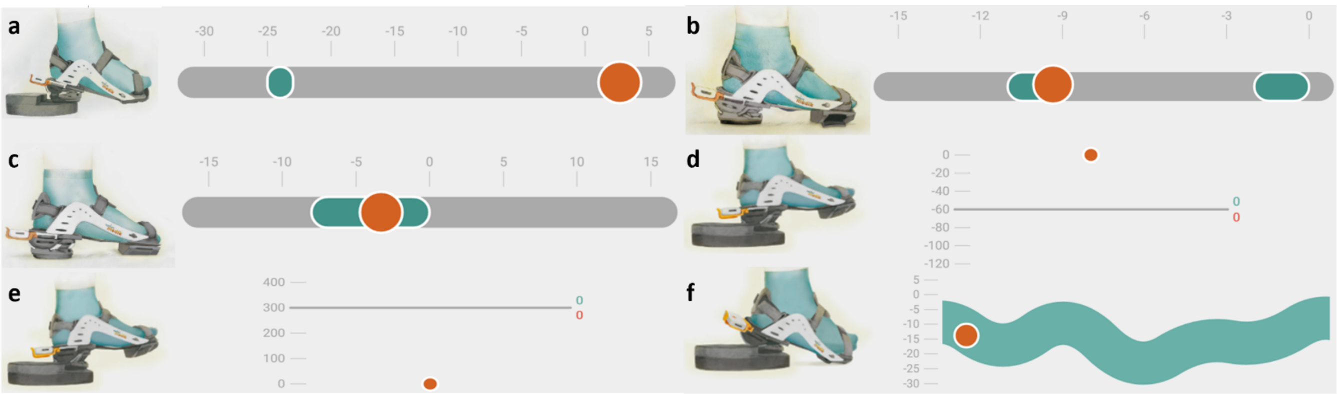

Figure 2. Ankle destabilization device test interface for proprioception and muscle strengthening tasks. Outcomes are reported as normalized performance scores (0–100%, higher values indicate better performance)

Table 3. Demographic characteristics of included subjects

Demographic data		Number of subjects	Percentages (%) or means (Standard deviation)
Age (years)		32	24.9 (3.1)
BMI (Kg/m^2)		32	23.4 (1.1)
Number of years as professional		32	6.5 (3.3)
Position	Offense	10	31.2 %
	Defense	9	28.1 %
	Goal	5	15.6 %
	Mid-fielder	8	25.0 %
Kicking foot	Right	22	68.8 %
	Left	10	31.2 %
Non-kicking foot	Right	10	31.2 %
	Left	22	68.8 %
History of knee injury non-kicking foot	No	21	65.6 %
	Yes	11	34.4 %
If yes	ACL	1	9.1 %
	MCL	1	9.1 %
	Lateral meniscus	4	36.4 %
	Osgood Schlatter	1	9.1 %
	Patellar tendinopathy	4	36.4 %
History of ankle injury Non-kicking foot	No	16	50.0 %
	Yes	16	50.0 %
If yes			
	Lateral sprain	14	87.5 %
	Medial sprain	1	6.2 %
	Fracture 5th metatarsal	1	6.2 %
History of knee injuryKicking foot	No	21	65.6 %
	Yes	11	34.4 %
If yes	MCL	1	9.1 %
	ACL	1	9.1 %
	MCL	1	9.1 %
	Lateral meniscectomy	1	9.1 %
	Osgood Schlatter	1	9.1 %
	Patellar tendinopathy	6	54.5 %
History of ankle injury Kicking foot	No	15	46.9 %

	Yes	17	53.1 %
If yes	Lateral sprain	14	82.4 %
	Medial sprain	1	5.9 %
	Distal fibular fracture	1	5.9 %
	Synovectomy of the peroneal tendons	1	5.9 %

BMI: Body mass index / ACL : Anterior cruciate ligament / MCL : Medial collateral ligament / PCL : Posterior cruciate ligament

Table 4. Main results for proprioception and strengthening tests for both feet

		Global (both feet)	Results non-kicking foot (%)	Results kicking foot (%)	p-value
Proprioception	Repositioning	59.5 +/- 23.7	56.4 +/- 25.8	62.7 +/- 21.4	n.s
	Dissociation	72.9 +/- 24.4	72 +/- 26.5	73.8 +/- 22.5	n.s
	Functional	95.2 +/- 13.6	93.6 +/- 15.9	96.8 +/- 10.7	n.s
Strengthening	Eccentric	86.4 +/- 20.9	88.8 +/- 17.3	83.9 +/- 23.9	n.s
	Concentric	61.3 +/- 29.5	57.7 +/- 30.9	65 +/- 27.9	n.s
	Functional	75.1 +/- 19.1	77.1 +/- 17.6	73.1 +/- 20.6	n.s

n.s: non-significant (when p-values > 0,05)

Results

Study population

Thirty-two professional players were included: 11 offense players, 12 mid-fielders, 11 defensive and 5 goalkeepers. None of the players was excluded from the study. Sixty-four ankles were analyzed. The demographic characteristics are reported in **Table 3**.

Biomechanical properties

The mean normalized performance scores were 59.5 ± 23.7% for repositioning proprioception and 61.3 ± 29.5% for concentric evertor muscle strength, expressed on a 0–100% scale (100% = best achievable performance) (**Table 4**).

The foot used (non-kicking vs kicking) did not influence the results of the proprioceptive assessment or muscular strength (**Table 4**).

None of the variables influenced the results of functional proprioception or functional, eccentric strengthening. midfielders (p <0.01), goalkeepers (p=0.03) and players who presented with a history of ankle injury in the non-kicking foot (p <0.01) had the best repositioning proprioception results. Goalkeepers had the highest dissociation proprioception values (p <0.01). Concentric evertor strength values increased with age (p <0.01), the number of years as a professional athlete (p<0.01), in subjects without a knee or non-kicking foot injury, (p=0.02) and in those without an ankle injury in the kick ing foot (p=0.05). The other results are reported in **Table 5**.

Discussion

The main findings of this study were that proprioception may vary according to the player’s position, while concentric evertor muscle strength appeared to be associated with age and experience as a high-level professional player.

Table 5: Impact of demographical data, playing position and professional experience on proprioceptive abilities and ankle evertor muscle strength

	Proprioception repositioning			Proprioception dissociation			Proprioception functional			Strengthening eccentric			Strengthening concentric			Strengthening functional		
	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Age	1.94	0.28, 13.30	n.s	0.51	0.07, 3.65	n.s	0.39	0.13, 1.14	n.s	1.59	0.29, 8.63	n.s	37.9	4.13, >100	<0.01	3.33	0.73, 15.30	n.s
BMI	0.20	0.00, 43.10	n.s	0.47	0.00, >100	n.s	1.13	0.05, 2.60	n.s	0.78	0.01, 88.80	n.s	0.48	0.00, >100	n.s	0.66	0.01, 50.40	n.s
Number of years as a professional	1.02	0.17, 6.30	n.s	0.45	0.07, 2.85	n.s	0.64	0.22, 1.82	n.s	0.82	0.16, 4.09	n.s	32.70	4.24, >100	<0.01	2.87	0.70, 11.80	n.s
Position played																		
Offense	-	-		-	-		-	-		-	-		-	-		-	-	
Defense	>100	0.01, >100	n.s	17.64	0.00, >100	n.s	0.15	0.00, >100	n.s	77.0	0.00, >100	n.s	0.02	0.00, >100	n.s	6.36	0.00, >100	n.s
Mid-field	>100	>100, >100	<0.01	2.89	0.00, >100	n.s	0.27	0.00, >100	n.s	0.00	0.00, 5.71	n.s	0.00	0.00, >100	n.s	0.01	0.00, >100	n.s
Goal	>100	15.20, >100	0.03	>100	40.90, >100	<0.01	44.70	0.00, >100	n.s	18.20	0.00, >100	n.s	0.03	0.00, >100	n.s	2.34	0.00, >100	n.s
History of injury to the non-kicking knee																		
No	-	-		-	-		-	-		-	-		-	-		-	-	
Yes	0.00	0.00, >100	n.s	49.7	0.00, >100	n.s	22.30	0.02, >100	n.s	0.06	0.00, >100	n.s	0.00	0.00, 0.04	0.02	0.85	0.00, >100	n.s
History of injury to the ankle of the non-kicking foot																		
No	-	-		-	-		-	-		-	-		-	-		-	-	
Yes	>100	>100, >100	<0.01	7.62	0.00, >100	n.s	0.10	0.00, 76.30	n.s	0.01	0.00, >100	n.s	26.6	0.00, >100	n.s	0.00	0.00, 10.80	n.s
History of injury to the kicking knee																		
No	-	-		-	-		-	-		-	-		-	-		-	-	
Yes	0.00	0.00, 67.20	n.s	99.40	0.00, >100	n.s	5.59	0.00, >100	n.s	>100	0.20, >100	0.10	0.00	0.00, 9.31	n.s	0.00	0.00, 7.67	0.13
History of injury to the ankle of the kicking foot																		
Non	-	-		-	-		-	-		-	-		-	-		-	-	
Oui	>100	0.01, >100	n.s	>100	0.05, >100	n.s	0.09	0.00, 74.30	n.s	0.00	0.00, 54.00	0.20	0.00	0.00, 0.74	n.s	0.00	0.00 6.23	0.12
1 OR = Odds Ratio, CI = Confidence Interval																		

n.s: non-significant (when p-values > 0,05)

Evertor weakness is a major risk factor for recurrent ankle instability [19][10]. Targeted strengthening, particularly eccentric training, is therefore recommended [20][21][22][23][17][18]. In professional soccer players, known risk factors for lateral ankle sprain include young age, inadequate warm-up or physical preparation, strength asymmetries, and fatigue [24][25]. In the present series, no differences were observed in functional or eccentric muscle strength, which may reflect the overall high level of physical preparation in professional athletes. Professionals have slightly more injuries during an entire season than amateurs (9.7/1000h vs 1.15 - 2.1/1000h) [2][26][27][28]. However, concentric evertor strength was higher in older and more experienced professionals, suggesting that younger players may be more prone to evertor strength deficits. Beyond strength, timely neuromuscular activation is also important. EMG studies have shown that physiological evertor preactivation occurs approximately 80–100 ms before ground contact [29][10][30], and delayed preactivation has been associated with chronic ankle instability [31]. In this context, the use of specific destabilizing devices has been reported to improve early preactivation [12][14]. Of note, multimodal prevention strategies combining neuromuscular and strengthening components have also been shown to influence evertor function: Lopes et al. demonstrated that the FIFA 11+ programme reduced evertor latency time and improved knee muscle strength in amateur futsal players [33], supporting the rationale for structured neuromuscular training protocols in soccer populations.

Proprioception training is often performed using non-specific unstable supports (foam or wobble boards), which may not directly target ankle control [32]. In contrast, dedicated devices focusing on hindfoot instability around the subtalar functional axis (Henke axis) may provide more specific proprioceptive stimulation.8 In our cohort, overall proprioception performance did not differ significantly across players; however, differences emerged according to playing position. Goalkeepers demonstrated the highest scores in both dissociation and repositioning tests, while midfielders showed the highest repositioning scores. To our knowledge, this is the first study reporting position-related differences in ankle proprioception in professional soccer players. These findings may reflect position-specific training demands, particularly in goalkeepers. Unlike muscle strength, proprioception outcomes were not influenced by age or years of professional experience. The clinical relevance of targeted balance training in this context is supported by McGuine and Keene, who reported that a structured balance-training programme reduced the incidence of ankle sprains in high-school athletes by approximately 38% [34], indicating that proprioceptive deficits including the position-dependent variations observed in our cohort represent a modifiable risk factor for ankle sprain.

Interestingly, previous ankle sprain/injury history and limb side (dominant vs non-dominant) did not influence strength or proprioception scores. This may be explained by the high quality of physical conditioning and structured rehabilitation protocols typically implemented at the professional level [20][25].

The ankle destabilization device allows objective assessment of proprioception and extrinsic muscle recruitment and may help identify subtle deficits not detected by routine testing. Moreover, beyond assessment, such devices may also support targeted rehabilitation programs. Overall, our results suggest that proprioceptive performance and evertor strength profiles in soccer players may vary with playing position and professional experience.

This study has limitations. All measurements were performed by a single trained examiner; while the device is considered easy to use in clinical practice [18]. While the device provides objective quantitative measurements, formal data on inter-examiner reproducibility and external validity remain limited and represent a study limitation. The cohort was small and included players from a single first-division team, limiting generalizability. The position-based comparisons should be interpreted cautiously due to limited sample size and multiple subgroup analyses, and are presented as exploratory findings. Finally, fatigue was not assessed and may have influenced performance. Future studies should confirm these findings in larger cohorts including multiple professional teams and should account for individual fatigue.

Conclusion

In this cohort of professional soccer players, ankle proprioception differed according to playing position, and concentric evertor strength was associated with age and professional experience. These results support position and experience specific neuromuscular screening to guide individualized ankle sprain prevention and rehabilitation programs in professional teams. Larger multicenter studies are needed to confirm these exploratory findings.

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Disclosure of interest

R. Lopes, A. Hardy and T. Bauer report consulting activities for Arthrex outside the submitted work. R. Lopes reports consulting activities for STEPS ORTHO, ENOVIS and EVOLUTIS outside the submitted work.

The other authors declare that they have no competing interests relevant to the content of this article.

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