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Neuromuscular profile in isometric force of hamstrings in professional soccer players of the AFC Champions League

Perfil neuromuscular en la fuerza isométrica de los Isquiotibiales en futbolistas profesionales de la Liga de Campeones de la AFC

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Abstract. Objective: The hamstring muscles in soccer are the region with the highest percentage of muscle injuries, due to numerous risk factors, including isometric strength levels. In this way, the aim is to know and establish a strength profile in this musculature in elite Asian players. Method: During the first part of the preseason, an elite soccer team (N=46 players) belonging to the AFC Champions League underwent isometric hamstring strength assessment at 30º and 90º, using a dynamometry device (ForceFrame ®, Valdperformace). Results: Among the results obtained, an average profile in Isometric Force (N) at 30º of 268 N (+- 46.4), an average profile of Isometric Force (N) at 90º of 206 N (+- 42.1) is observed), a bilateral asymmetry (%) at 30º of 2.23% (+- 12.2) and a bilateral asymmetry (%) at 90º of 6.46% (+- 15.9). Regarding the correlation between measured variables, a moderate positive correlation (0.732, p=0,001) is observed between the average of bilateral Isometric Strength (N) at 30º and at 90º. Conclusions: In light of the results obtained, it is observed that the players in the present sample present higher levels of isometric strength at 30º than at 90º, nevertheless presenting higher % of bilateral asymmetry at 90º compared to 30º.
Keywords: Neuromuscular, Hamstring, injuries, Strength, Isometric

Resumen. Objetivo: Los músculos isquiotibiales en el fútbol son la región con mayor porcentaje de lesiones musculares, debido a numerosos factores de riesgo, entre ellos los niveles de fuerza isométrica. De esta forma, se pretende conocer y establecer un perfil de fuerza en esta musculatura en jugadores de élite asiáticos. Método: Durante la primera parte de la pretemporada, un equipo de fútbol de élite (N=46 jugadores) perteneciente a la Liga de Campeones de la AFC se sometió a una evaluación isométrica de la fuerza de los isquiotibiales a 30º y 90º, utilizando un dispositivo de dinamometría (ForceFrame ®, Valdperformace). Resultados: Entre los resultados obtenidos se observa un perfil promedio de Fuerza Isométrica (N) a 30º de 268 N (+- 46.4), un perfil promedio de Fuerza Isométrica (N) a 90º de 206 N (+- 42.1).), una asimetría bilateral (%) a 30º de 2,23% (+- 12,2) y una asimetría bilateral (%) a 90º de 6,46% (+- 15,9). En cuanto a la correlación entre las variables medidas, se observa una correlación positiva moderada (0,732, p=0,001) entre el promedio de la Fuerza Isométrica (N) bilateral a 30º y a 90º. Conclusiones: A la luz de los resultados obtenidos, se observa que los jugadores de la presente muestra presentan mayores niveles de fuerza isométrica en 30º que en 90º, sin embargo, presentan mayor % de asimetría bilateral en 90º respecto a 30º.
Palabras clave: Neuromuscular, Isquiosurales, Lesiones, Fuerza, Isometrica

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Introduction

Hamstring strength is crucial for soccer players due to its role in injury prevention and sports performance. A recent study on hamstring injuries in professional football, published in the British Journal of Sports Medicine in 2023 (1), shows a considerable increase in the incidence of these injuries. The data spans 21 seasons (2001/02-2021/22) and reveals that hamstring injuries now account for 24% of all injuries in top-level men's football, compared to 12% at the start of the study. Furthermore, these injuries are responsible for 20% of all injury-related days of absence, reflecting their impact on team performance. This increase suggests that current prevention programmes are not being fully effective. The hamstrings are responsible for knee flexion and hip extension, essential movements in high-intensity actions such as sprints and changes of direction, which are frequent in soccer.(1) Furthermore, the importance of hamstring strength lies in the more specific actions in football such as acceleration and vertical jump (2). Furthermore, its role is essential in sprint and acceleration mechanics, as some studies show, acceleration phase and maximum speed during sprinting, a key skill in football. Thus, evidence has shown that greater strength and power in the hamstring muscles is correlated with better sprint times (3)

It has been proven that hamstring muscles with optimal strength values help prevent muscle injuries, which are common in soccer due to the high demand in high-intensity actions, something that has been occurring in recent years in elite soccer (4) Studies have shown that adequate hamstring strength can reduce the risk of injuries, especially those caused by high-speed sprinting (5).

Furthermore, the importance lies not only in relation to injury prevention, but also in the recovery and rehabilitation and reconditioning processes of an injury. Thus, there is evidence that deficiencies in hamstring strength can persist even after returning to competition after an injury, which can affect performance and increase the risk of recurrence (6) Recent evidence (1) that analyzes hamstring injury rates, highlights the need for specific preventative programs, including eccentric exercises and individualized programs to reduce the risk of injury in professional football. And one of the pillars that relate sprint performance and hamstring injuries is the relationship between those sprint demands and eccentric strength levels. Latest researches (7) examines the relationship between weekly sprint volume and eccentric hamstring strength. The main conclusion is that they found that a greater amount of Sprints at speeds greater than 90% of maximum speed can significantly decrease eccentric hamstring strength, underscoring the importance of monitoring and adjusting speed training to prevent injury (7,8,9)

The key to being able to implement appropriate tools that influence the neuromuscular improvement of this muscle is to objectively evaluate it using validated procedures in relation to laboratory gold standards (10,11), showing that these devices show a high level of reliability and reproducibility. In addition, other studies have previously used dynamometric devices for the evaluation of force profiles in hamstring muscles (12), so it could be considered a tool with sufficient objectivity, reliability and validity to assessment isometric force (13)

Currently, there is little evidence in relation to the neuromuscular profile of the professional soccer player of Asian origin. In this regard, studies have shown that professional players from Hong Kong have a lower level of physical abilities related to muscle power and jumping ability than European players of the same competitive level (14). In another study, players of Asian origin (Hong Kong) are shown to have poor levels of isokinetic hamstring strength, and low Hamstring-Quadriceps strength ratio (HQ Ratio), and previous injury, are exposed to a greater risk of injuries to these muscles (15).

Due to this gap in the scientific literature regarding the neuromuscular profile of the Asian hamstring player, the objective of the present study is to show the isometric hamstring strength profile in top-level players from Malaysia, who participate in the AFC Champions League (maximum competition Asian continental). The objectives are to show the average profile of isometric hamstring strength in both the medial and lateral hamstring muscles, the average profile of bilateral asymmetries in both muscles and to analyze the correlation between the strength levels at the medial and lateral level of the hamstring muscles (biceps femoris, semitendinosus- membranous)

Method

Study participants

On this Observational Descriptive Study, 46 elite soccer players belonging to a Malaysian professional club that participates in the AFC Asian Champions League during the 2024-25 season (28 years +-2.1; 1.77cm +-3.5; 22.1BMI +-1.98; 14.3% fat +- 1,1; 75.4kg +-2.9), with an average of 7.2years in professional level formed the sample of this study. These players were selected directly, as they are all part of this specific team. The sampling technique used in the study is convenience sampling. This type of sampling involves selecting participants who are readily available to the researchers. The sampling technique used in the study is convenience sampling. There was no random or stratification process, which characterizes this type of non-probabilistic sampling. In this case, the 46 players from the Malaysian professional football club were chosen because they belong to the team under study during the 2024-2025 season and met the established criteria (not being injured in the last 30 days). There was no random or stratification process, which characterizes this type of non-probabilistic sampling. The purpose of the study was explained in detail to all players to participate in the research. They were informed that all data collected in this study would be kept confidential and that only medical and technical staff would have access to this data confidentially.

During a brief medical history interview by the medical services and the performance department (1 doctor, 3 physical therapists and 3 strength-conditioning coaches), the participating subjects reported that they were not injured, nor had they been injured in the last 30 days. . These indications were confirmed by the medical staff of this team through regular medical examinations (imaging tests, clinical history and on-site clinical evaluation).

Table 1.
Data from the study sample
Age: Chronological age in years; Height: Height measured in centimeters (cm); Weight: Body mass measured in Kilograms (Kg); BMI: Body Mass Index; % Fat: Percentage of body fat mass;

Age	28 +- 2.1 years
Height	1.77+-3.5cm
Weight	75.4 +- 2.9kg
BMI	22.1 +- 1.98
% Fat	14.3 +- 1.1
Professional years	7.2 years

Procedures

The measurement tools were Neuromuscular Assessment and Monitoring System (ValdPerformance ForceFrame®), used to assess hamstring strength (biceps femoris, semitendinosus, and semimembranosus) in two joint range positions (30º and 90º). This device is capable of measuring muscle strength and detecting imbalances or asymmetries between the sides of the body. ValdPerformance and ValdHub Software, used to process data obtained through the ForceFrame®. The software allows auto-detection of repetitions and maximum strength values, averages, and asymmetries, eliminating repetitions that do not comply with the protocol. The measurement processes were carried out during the first and second week of preseason, at the same time of day (9:30 am) and following the same order of session structure. Furthermore, all tests were carried out following the protocols shown (16). In this case, two positions and joint ranges (30º and 90º) were used to evaluate the muscles of the biceps femoris and the semitendinosus and semimembranosus respectively.

In a simply and unique evaluation , the test was carried out for all players 5 minutes after finishing the standardized warm-up (17) , with 5 minutes of cycling and 5 minutes of active lower limb mobility exercises. For all subjects, for each test there was a demonstration and repetition of the test to check the correct execution of the test. During the execution of the test, 3 maximum repetitions of 3 seconds were performed with 2 minutes of recovery between them

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(17) During the test execution, standardized verbal instructions for maximum contraction were used. (10,11,12,13,16 ,17)

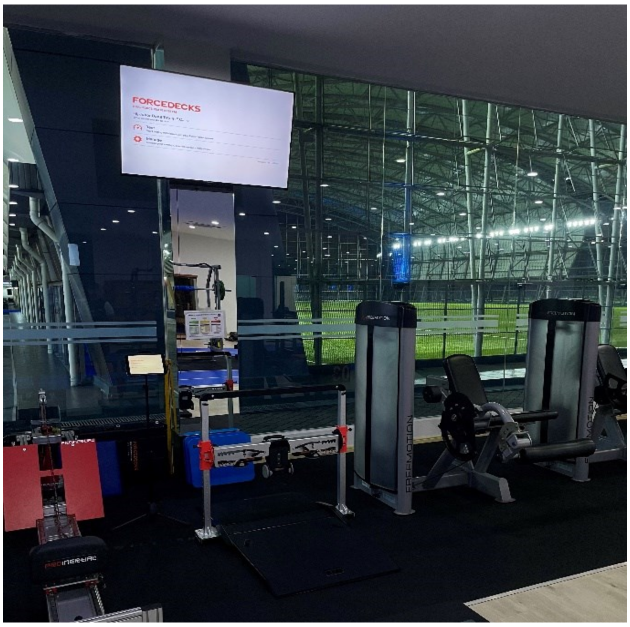

Figure 1. Neuromuscular Assessment and monitoring System (Forceframe ® , Valdperformance , VALD, Brisbane, Australia)

For data processing, the specific ValdPerformance Software and ValdHub cloud system (APP ForceFrame, Apple Store, Vald Performance Pty Ltd © 2014-2024,Version 2.1.0) was used, using the default configuration. This analysis involved self-detection of the repetitions and the maximum force values, averages and asymmetries. The repetitions that were not performed accordingly to the protocol and standards, were eliminated from subsequent analysis (10)

Statistic analysis

The data were first analyzed to determine accuracy of data collection, missing values, and outliers. To calculate correlations, the Pearson Correlation Coefficient (r) was used, establishing the following correlation levels: 1 (Large and perfect negative correlation), -0.9to -0.99 (Very high negative correlation), -0.7 to -0.89 (High negative correlation), -0.4 to -0.69 (Low negative correlation), -0.2 to -0.39 (Low negative correlation), -0.01 to -0.19 (Very low negative correlation), 0 (No correlation), with the same interpretation for positive correlations.

For the statistical analysis, the correlation matrix between the different variables of the study, a heat map of correlations, in addition to the descriptive values (Mean, median, standard deviation, maximum, minimum and 25th, 50th and 75th percentiles) was made using the Software Jamovi Stats ® 2.5.4 version Deskotp for Mac (https://dev.jamovi.org)

In relation to ethical considerations, they were taken into account to protect the rights and well-being of participants in sports research, complying with ethical principles of autonomy, confidentiality and non-maleficence.

Results

The results of the analysis of isometric hamstring strength in elite soccer players show important differences between the muscles and angular positions evaluated, which has relevant implications for training and injury prevention.

Isometric Strength at 90º

Analysis of the results (Figure 3) reveals that the average isometric force at 90º for the semitendinosus and semimembranosus muscles is 256 N (± 31.6) on the right side and 209 N (± 45.2) on the left side, showing a significant difference between both sides. This asymmetry is reflected in an average bilateral force profile of 206 N (± 42.1) (Figure 4) and an average bilateral asymmetry of 6.46% (± 15.9) (Figure 5).

Figure 2.
Descriptive Values of Neuromuscular Parameters in Hamstring Muscles (Isometric Force N)

Descriptive Analysis									
		RIGHT ISO HAMS 90º	LEFT ISO HAMS 90º	ISO AVERAGUE 90º	% ASSYM 90º	RIGHT ISO HAMS 30º	LEFT ISO HAMS 30º	AVERAGUE ISO HAMS 30º	% ASSYM 30º
N	46								
Averague		256	209	206	6.46	268	262	262	-2.23
Median		266	202	208	3.67	258	255	258	-715
Standard Desvest (+-)		31.6	45.2	42.1	15.9	46.4	46.9	41.8	12.2
Mín		159	92.0	121	-24.0	177	152	165	-42.3
Max		286	301	306	62.0	379	387	351	18.4
25percentil		257	179	176	-2.41	235	229	236	-12.4
50percentil		266	202	208	3.67	258	255	258	-715
75percentil		276	240	235	13.6	299	300	295	5.91

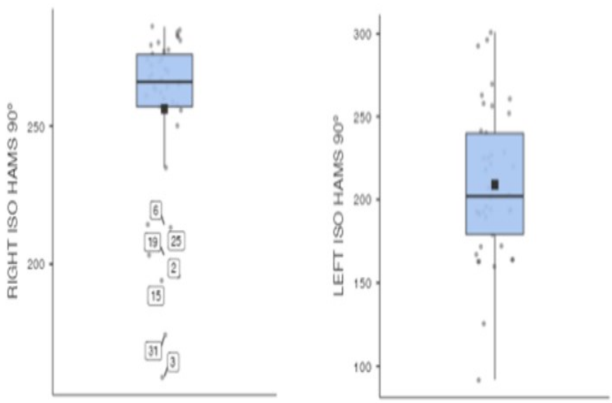

Figure 3. Average Unilateral Force Values (N) Isometric Hamstring (90º) (A) Right side (B) left side)

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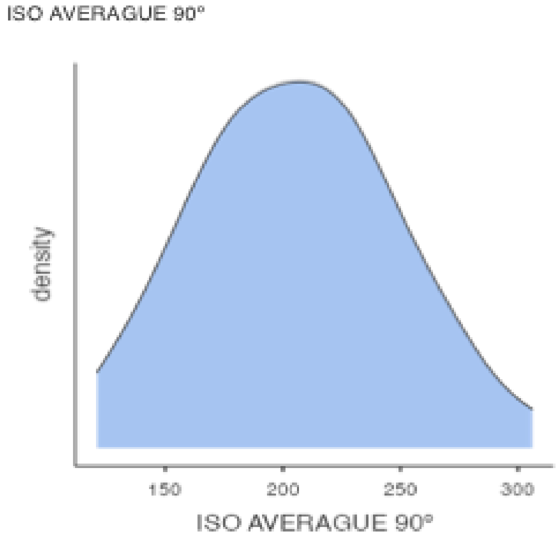

Figure 4. Density in Bilateral Average Strength Values (N) Isometric Hamstring (90º)

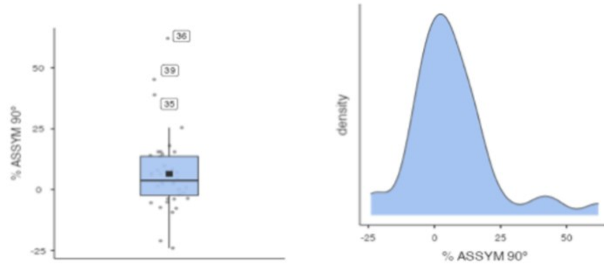

Figure 5. Bilateral asymmetry in Hamstring Strength (90º) (A) Average values and standard deviation, (B) Density

Isometric Strength at 30º

Regarding the biceps femoris (30º), the results (Figure 6) indicate an average force profile of 268 N (± 46.4) on the right side and 262 N (± 46.9) on the left side. The average bilateral profile for 30º is 262 N (± 41.8) (Figure 7 and 9), with a bilateral asymmetry of -2.23% (± 12.2).

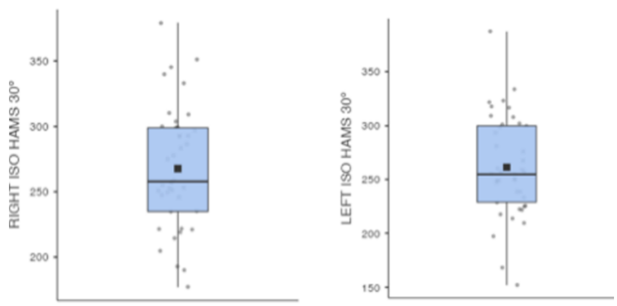

Figure 6. Average Unilateral Force Values (N) Isometric Hamstring (30º) (A) Right side (B) left side)

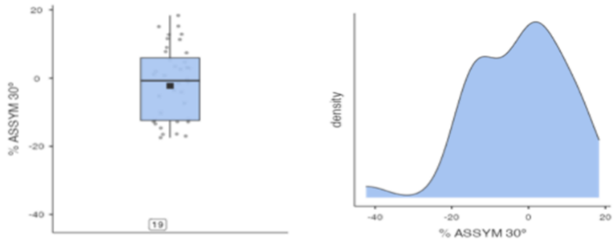

Figure 7. Bilateral asymmetry in Hamstring Strength (30º) (A) Average values and standard deviation, (B) Density Partial plot

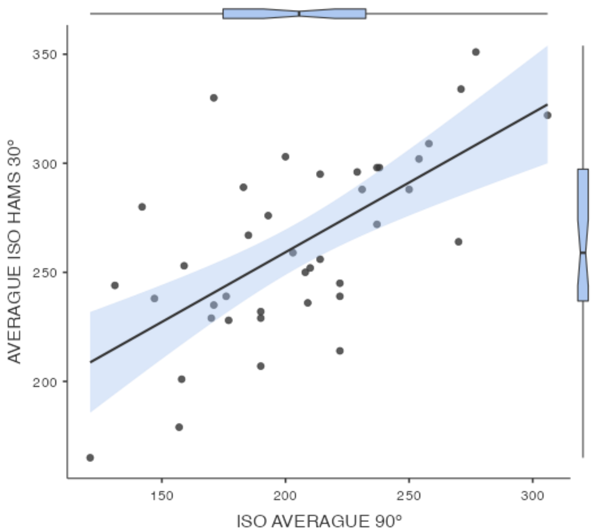

Figure 9. Average Scatter Graph Hamstring Isometric Force (N) at 90º and at 30º. Correlation heat map

Correlations between Variables

The moderate correlation observed between the isometric force values at 30º on the left side and the force values at 90º on the left side ($r = 0.732$, $p < 0.001$) (Table 2, Figures 8 and 10) indicates that, although the angular positions and specific muscles have different strength profiles, there is a significant relationship between them. This suggests that strengthening programs that improve strength in one angular position could have indirect benefits in other positions, although with individual variability.

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Table 2.
Partial Correlation Matrix between variables (Isometric Hamstring Strength (N) at 90º and at 30º)

		Correlation Matrix					
		RIGHT ISO HAMS 90º	LEFT ISO HAMS 90º		RIGHT ISO HAMS 30º		LEFT ISO HAMS 30º
RIGHT ISO HAMS 90º	r	—					
	p-value	—					
LEFT ISO HAMS 90º	r	0.077	—				
	p-value	0.535	—				
RIGHT ISO HAMS 30º	r	-0.091	0.499	***	—		
	p-value	0.463	< .001		—		
LEFT ISO HAMS 30º	r	0.161	0.732	***	0.775	***	—
	p-value	0.193	< .001		< .001		—

Note. Not controlling for any variables, the result table shows Pearson correlation matrix
Note. Two-tailed significance: * p < .05, ** p < .01, *** p < .001

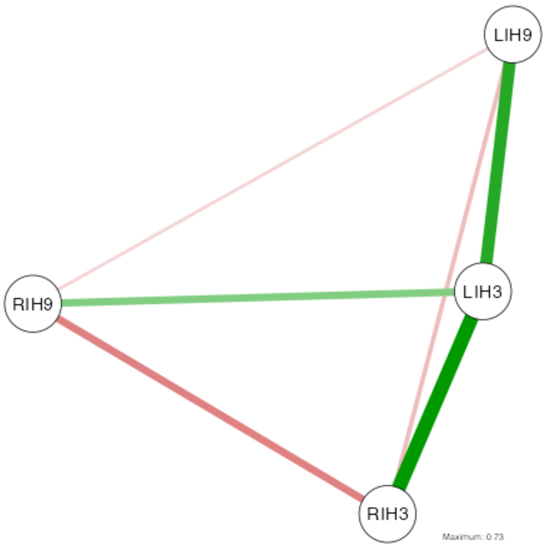

Figure 8. Partial Plot of Partial Correlations in Hamstring Strength (RIH9 Isometric Strength right side 90º; RIH3 Isometric Strength right side 30º, LIH3 Isometric Strength Left Side 30º,LIH9 Isometric Strength left side 90º)

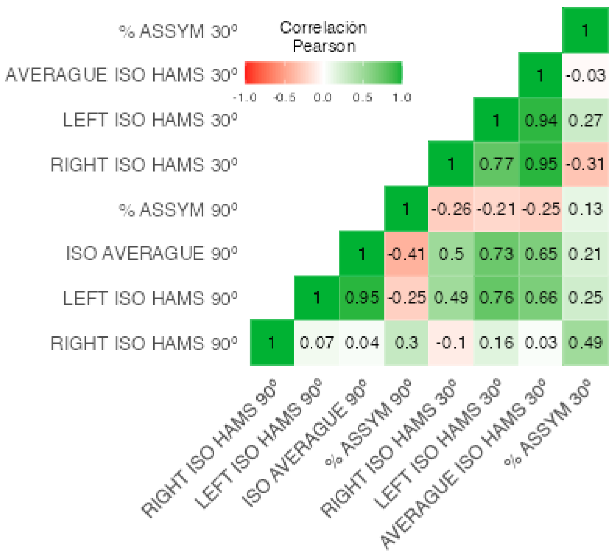

Figure 10. Heat Map of Correlations between study variables (Isometric Strength (N) at 30º and 90º on the right and left sides, bilateral average and % asymmetry)

Discussion

According with related research, an study on eccentric hamstring strength profile in elite South Korean players. (22) This study evaluated professional soccer players using devices such as the NordBord Hamstring Testing System to measure eccentric hamstring strength. The results showed that greater eccentric strength was correlated with a lower risk of hamstring injuries and highlighted the importance of integrating specific exercises into training programs. Another research on strength asymmetry in Japanese soccer players (23), study published in the Journal of Strength and Conditioning Research examined the asymmetry between the dominant and non-dominant leg hamstring muscles in elite players from Japan. It was concluded that the presence of asymmetries increased the predisposition to injury. As a result of the results obtained, in relation to the 90º profile, the differences shown may indicate a predisposition to muscle imbalances, which are risk factors for injuries in football. (5).The significantly lower strength on the left side suggests that players could benefit from specific training programs that address these asymmetries. Studies have shown that imbalances in hamstring strength can increase the risk of injury, especially during explosive movements such as sprints and changes of direction (1). Anyway, the evidence substantiating lower limb functional asymmetry as a risk factor for sporting injuries is moderate to low quality (24)

Unlike the 90º force, the 30º isometric force shows a negative bilateral asymmetry, indicating greater equality between the right and left sides. This greater symmetry at 30º suggests that players could be better adapted to strength in more extended positions (18), which is important for movements that require rapid leg extensions, such as kicking and high-speed running.

Other references (18) have shown that the 90º isometric force of the hamstrings in professional soccer players ranged from around 280 N to 300 N for the dominant side, with an average asymmetry of 10-15% in players who had not performed specific eccentric strengthening programs. Compared to this study, the values obtained in our analysis are slightly lower, which could suggest differences in levels. of training or in the methodologies used to measure strength, or due to lesser strength adaptations of the muscles involved. Some evidences (20) was observed that rugby players showed a 30º isometric force for the biceps femoris of approximately 270 N (± 30) in the dominant side and 260 N (± 35) on the non-dominant side. These values are comparable to those obtained in our analysis (268 N and 262 N, respectively), suggesting that the hamstring strength profiles at 30º may be similar between each other. different high intensity sports, such as football and rugby.

Finally, in a longitudinal study (21) where the eccentric strength of the hamstrings was measured in soccer players, finding that the players who participated in specific strengthening programs eccentric showed a significant reduction in strength asymmetry, going from an average asymmetry of 15% to less than 5%. In comparison, our study shows an average asymmetry of 6.46% at 90º and -2.23% at 30º, which could indicate. a good implementation of strengthening and prevention programs in our analyzed players.

Regarding the limitations of the present study, we can indicate sample size, since it may be insufficient to generalize the results to all elite soccer players. A small number of participants may affect the statistical robustness of the findings and their applicability to a broader population of gamers.

Another limitation may be that the data obtained reflect a specific moment in time (preseason). Variations in muscle strength over the course of a season, influenced by training load and matches played, have not been considered, limiting the understanding of how hamstring strength can vary and how it should be managed throughout the season.

Practical Implications

Muscle Asymmetry

The asymmetry observed in our analysis for 90º isometric strength suggests the need for specific training programs to balance strength between the right and left sides. Eccentric strengthening programs and mobility exercises can be effective in reducing these asymmetries and reducing injury risk.

Comparison with Normative Values

The strength values obtained in our analysis are comparable with other studies, although they show differences that could be influenced by variations in the training level, the measurement technique, and the individual characteristics of the players. This underlines the importance of adapting training programs to the specific needs of each team and player.

Continuous Monitoring

Implementing continuous monitoring of hamstring strength can help identify muscle imbalances before they become a significant problem, allowing for early, personalized interventions to improve strength and reduce the risk of injury in players.

Eccentric Strength Hamstring exercises

Incorporate specific eccentric strengthening exercises, such as the Nordic Hamstring Curl, or the deadlift (knee- and hip-dominant) into training programs. These exercises can help increase eccentric hamstring strength, reducing the risk of injury.

In conclusion, the results of our study (isometric force at 90º for the semitendinosus and semimembranosus muscles is 256 N (± 31.6) on the right side and 209 N (± 45.2) on the left side; Regarding the biceps femoris (30º), the results indicate an average force profile of 268 N (± 46.4) on the right side and 262 N (± 46.9) on the left side) provide a valuable comparison with other strength profiles in soccer players, highlighting the importance of addressing muscle asymmetries and implementing specific strengthening programs to optimize performance and injury prevention.

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