Spor ve Performans Araştırmaları Dergisi,
Journal of Sports and Performance Researches

e-ISSN: 1309-8543 Spor ve Performans Araştırmaları Dergisi,
Aralık 2023, 14(3): 419-428

The Relationship Between Hamstring Shortness and Postural Control in Football Players: A Pilot Study

Futbolcularda Hamstring Kas Kısalığı ve Postüral Kontrol Arasındaki İlişki: Pilot Çalışma

Ömer ÇALIŞKAN[1], Bayram Sönmez ÜNÜVAR[2], Abdullah ARGUZ[3], Furkan KORKUSUZ[4], Ramazan GÖĞEBAKAN[5], Nurtekin ERKMEN[6]

[1]School of Physical Education and Sports, Kilis 7 Aralık University, Kilis
· **cliskanomer@gmail.com** · ORCİD > 0000-0003-3885-000

[2]Department of Audiology, Faculty of Health Sciences, KTO Karatay University, Konya
· **sonmezunuvar@gmail.com** · ORCİD > 0000-0003-2095-3645

[3]Faculty of Sports Sciences, Selcuk University, Konya
· **aarguz46@gmail.com** · ORCİD > 0000-0002-0616-2735

[4]Faculty of Sports Sciences, Selcuk University, Konya
· **furkankorkusuz0@gmail.com** · ORCİD > 0000-0001-6570-3952

[5]Faculty of Sports Sciences, Selcuk University, Konya
· **rgogebakan46@gmail.com** · ORCİD > 0000-0002-9761-6834

[6]Faculty of Sports Sciences, Selcuk University, Konya
· **nerkmen@selcuk.edu.tr** · ORCİD > 0000-0002-5220-887X

Makale Bilgisi/Article Information

Makale Türü/Article Types: Araştırma Makalesi/Research Article
Geliş Tarihi/Received: 15 Eylül/September 2023
Kabul Tarihi/Accepted: 8 Aralık/December 2023
Yıl/Year: 2023 | **Cilt – Volume:** 14 | **Sayı – Issue:** 3 | **Sayfa/Pages:** 419-428

Atıf/Cite as: Çalışkan, Ö., Ünüvar, B. S., Arguz, A., Korkusuz, F., Göğebakan, R., Erkmen, N. "The Relationship Between Hamstring Shortness and Postural Control in Football Players: A Pilot Study" Ondokuz Mayıs University Journal of Sports and Performance Researches, 14(3), Aralık 2023: 419-428.

Sorumlu Yazar/Corresponding Author: Abdullah ARGUZ

Etik Kurul Beyanı/Ethics Committee Approval: "Araştırma için Selçuk Üniversitesi Girişimsel Olmayan Klinik Araştırma ve Yayın Etiği Kurulu'ndan 26.01.2023 tarihli ve 17 karar sayısı ile etik kurul izni alınmıştır."

https://doi.org/10.17155/omuspd.1361009

THE RELATIONSHIP BETWEEN HAMSTRING SHORTNESS AND POSTURAL CONTROL IN FOOTBALL PLAYERS: A PILOT STUDY

ABSTRACT

Hamstring muscles significantly contribute to lower limb mobility and overall body balance. Specifically, hamstring muscle tightness has been suggested as a potential factor affecting an athlete's postural control. Therefore, this study aims to contribute to the ongoing discourse by investigating the possible relationship between hamstring muscle tightness and postural control among football players. Sixteen male football players (mean age: 20.19 ± 2.17 years, body mass index: 22.01 ± 1.82 kg/m2) with hamstring muscle tightness participated in this cross-sectional study. The assessment of hamstring muscle tightness was conducted through the Active Knee Extension Test. Additionally, the participants' postural control was evaluated using the Biodex Balance System. The correlation between Active Knee Extension Angle and Postural Control was analyzed through Spearman correlation test. No significant relationship was found between the active knee extension angles of both dominant and non-dominant legs and the postural control measurements ($p > 0.05$). The study revealed a lack of correlation between active knee extension angle and postural control among football players with hamstring muscle tightness. These findings indicate that hamstring muscle tightness may not impact postural control. Furthermore, it is observed that research involving broader and more diverse participant groups is needed to comprehensively understand this relationship.

Keywords: Football, Hamstring Muscles, Postural Balance.

❋❋❋

FUTBOLCULARDA HAMSTRİNG KAS KISALIĞI VE POSTÜRAL KONTROL ARASINDAKİ İLİŞKİ: PİLOT ÇALIŞMA

ÖZ

Hamstring kasları alt ekstremite hareketliliğine ve genel vücut dengesine önemli ölçüde katkıda bulunur. Özellikle, hamstring kas gerginliğinin bir sporcunun postüral kontrolünü etkileyen potansiyel bir faktör olduğu öne sürülmüştür. Bu nedenle, bu çalışma futbolcular arasında hamstring kas gerginliği ve postüral kontrol arasındaki olası ilişkiyi araştırarak litaretüre katkı sağlamayı amaçlamaktadır. Bu kesitsel çalışmaya hamstring kas gerginliği olan 16 erkek futbolcu (ortalama yaş: 20,19 ± 2,17 yıl, vücut kitle indeksi: 22,01 ± 1,82 kg/m2) katılmıştır. Hamstring kas gerginliğinin değerlendirilmesi Aktif Diz Ekstansiyon Testi ile yapılmıştır. Ayrıca, katılımcıların postüral kontrolü Biodex Denge Sistemi kullanılarak değerlen-

dirilmiştir. Aktif Diz Ekstansiyon Açısı ve Postüral Kontrol arasındaki korelasyon Spearman korelasyon testi ile analiz edilmiştir. Hem dominant hem de non-dominant bacakların aktif diz ekstansiyon açıları ile postüral kontrol ölçümleri arasında anlamlı bir ilişki bulunmamıştır ($p > 0,05$). Çalışma, hamstring kas gerginliği olan futbolcularda aktif diz ekstansiyon açısı ile postüral kontrol arasında korelasyon olmadığını ortaya koymuştur. Bu bulgular, hamstring kas gerginliğinin postüral kontrolü etkilemeyebileceğini göstermektedir. Bununla birlikte, bu ilişkiyi kapsamlı bir şekilde anlamak için daha geniş ve daha çeşitli katılımcı gruplarını içeren araştırmalara ihtiyaç olduğu görülmektedir.

Anahtar Kelimeler: Futbol, Hamstring, Postüral Kontrol.

❋❋❋

INTRODUCTION

Today, football captures the spotlight for being both an exhilarating spectacle for the masses and a cutting-edge domain of sports science. Within this distinctive sport, football players engage in competition demanding not only finely-tuned physical balance and coordination but also the display of strategic brilliance on the field (Bigoni et al., 2017; Stolen et al., 2005). Football stands as a realm teeming with actions like swift sprints, abrupt shifts in stance, impressive leaps, and lightning-fast responses to the ball. Such an array of movements and their high intensity necessitate that football players maintain peak physical condition while adeptly guiding and harmonizing their bodies (Mohammadi Nia Samakosh et al., 2022).

Attaining both successful performance and minimizing injury risks in football players is a multifaceted challenge. This challenge revolves around intricately managing the interactions among the body's diverse muscle groups (Mandorino et al., 2023; Pfirrmann et al., 2016). Notably, the interplay between hamstring muscles and postural control establishes a crucial framework that significantly impacts the on-field prowess and enduring athletic careers of football players (Diker et al., 2022; Śliwowski et al., 2021).

The hamstring muscles constitute a vital muscle cluster positioned at the back of the leg, governing a range of leg motions. These muscles assume a pivotal function by furnishing the power necessary for swift dashes, offering equilibrium and command while executing ball kicks, and ensuring steadiness amid abrupt shifts in stance (Afonso et al., 2021). Nonetheless, extended periods of sitting stemming from contemporary lifestyles, insufficient physical engagement, and a lack of proper stretching routines frequently culminate in the contraction of hamstring muscles (Shukla & Patel, 2021). The tightening of these muscles can have adverse consequences, casting a shadow over athletic performance and amplifying injury susceptibility among football players (Cai et al., 2023).

Football, a sport requiring intricate coordination and balance, is contingent upon various factors influencing athletes, especially the interaction between hamstring muscle tightness and postural control. While hamstring muscles play a pivotal role in facilitating agility and stability, the precise correlation between hamstring tightness and postural control in football remains a subject ripe for investigation. This study endeavors to bridge this gap by scrutinizing the potential relationship between hamstring muscle tightness and postural control among football players. In light of this information, the aim of this study is to investigate the relationship between hamstring muscle tightness and postural control in football players. The study will delve into how the suppleness of hamstring muscles interplays with postural control, while also scrutinizing how this connection influences both football performance and the well-being of players. The hypothesis of this study was that increased hamstring tightness may affect the postural control abilities of footballers.

METHOD

Protocol

This was a cross-sectional prospective study. This study was approved by Selçuk University (Decision Date: 26.01.2023; Decision no: 17). This study has been reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement to assist in quality reporting.

Participants

The study encompassed 16 male amateur football players within the age range of 18 to 30 possessing a valid football license. Inclusion criteria stipulated the absence of any hamstring injury within the preceding 3 months and a demonstrated restriction exceeding 20 degrees in the active knee extension test. All of the football players who participated in our study had hamstring muscle tightness because there was a restriction exceeding 20 degrees in the active knee extension test. Exclusion criteria comprised individuals with a surgical history linked to hamstring or other lower extremity muscles, those afflicted by chronic illnesses or muscle disorders, as well as individuals grappling with prevailing motor control issues, neurological, or vestibular disorders. They were actively engaged in training at least 3 days a week in the preparation season. All participants received instructions to abstain from alcohol, caffeine, and strenuous exercise 48 hours prior to the measurements. During the study, participants followed their regular diet, except on training days between 16:00 and 18:00. On the designated measurement day, the participants underwent hamstring muscle length assessment before proceeding to the postural control test.

Outcome Measures

Active Knee Extension Test: The evaluation of hamstring muscle tightness involved conducting an active knee extension test for both the dominant and non-dominant legs separately. To commence, the athlete assumed a supine position, with the non-tested leg fully extended, while the leg being tested was flexed at a 90-degree angle in the hip joint, initiating the test with the knee in a flexed position. Participants were then instructed to maximize knee straightening, aiming to achieve full knee extension. Throughout this process, a goniometer, positioned alongside the knee and aligned with the lateral condyle of the femur, was utilized. The stationary arm aligned with the greater trochanter, while the mobile arm aligned with the lateral malleolus, allowing measurement when the participant surpassed the 90-degree hip angle. The degree required to reach full knee extension was recorded. Importantly, the ankle maintained its neutral position both at the test's beginning and throughout the duration. An inability to extend the knee by more than 20 degrees was deemed indicative of compromised muscle functionality (Barbosa et al., 2017; Hansberger et al., 2019) aged between 18 and 28 years old, were randomly included in three groups: control (Cg, n = 18).

Postural Control: The study employed the Biodex Balance System to evaluate the postural control performance of the participants. This system involves conducting postural sway tests on a platform with a full 360° range of motion, carried out both with participants having their eyes open (EO) and with their eyes closed (EC). The platform's mobility can be adjusted to match various levels of difficulty; higher difficulty settings lead to greater platform movement (Kocaoglu & Girgin, 2023).

Participants underwent postural control assessments by balancing on one leg, specifically on their dominant leg. The determination of the dominant leg was based on their preferred leg for striking a ball, established before the measurements commenced. Before the actual measurements, participants were provided time to acclimate themselves and perform adequate repetitions to minimize the influence of the learning curve. Subsequently, participants were instructed to stand on the Biodex Balance System's platform with bare feet and adopt a single-leg stance using their dominant leg. They were then guided to lift their non-dominant legs slightly off the ground and place their hands diagonally on their shoulders. The task involved maintaining equilibrium by utilizing the center of gravity projection displayed on the platform's screen. During the test, participants were required to sustain their stance for 20 seconds without relying on visual cues, performing the trial both with their eyes closed and without visual feedback. Each condition was repeated twice, and the most favorable outcomes were recorded. Following each measurement, a 60-second break was provided. In instances where participants couldn't complete the test, the assessment was discontinued and repeated. The measurements yielded overall postural control scores, as well as anterior-posterior and medio-lateral sway scores. The study design included ample breaks between each measurement to ensure accuracy and consistency (Cachupe et al., 2001).

Statistical Analyses

The research findings were transformed into basic statistics including mean, standard deviation, minimum and maximum values. Normality of the data was evaluated using Shapiro-Wilk test. Spearman correlation analysis was used to determine the correlations between variables. The α level was set at $p < 0.05$. SPSS (Version 26.0) statistical software package program was used to analyze the data.

RESULTS

Table 1 displays the descriptive characteristics of the participants. The athletes had an average age of 20.19±2.17 years, stood at an average height of 179.00±4.95 cm, and had an average body weight of 70.44±5.15 kg.

Table 1. Sociodemographic information of study participants (n=16).

Variables	Mean	Sd	Min.	Max.
Age (years)	20.19	2.17	18.00	26.00
Height (cm)	179.00	4.95	173.00	191.00
Weight (kg)	70.44	5.15	62.00	82.00
Sports Experience (years)	5.81	2.07	3.00	9.00

cm: centimeter; kg: kilogram

Table 2 outlines the scores for active knee extension and postural control.

Table 2. Degrees of active knee extension and postural control scores.

			Mean	Sd	Min.	Max.
	Active Knee Extension (°)	Dominant	43.50	6.01	32.00	55.00
		Non-dominant	46.88	5.64	36.00	55.00
Open Eyes	Dominant	PC	3.41	1.08	1.80	5.80
		AP	2.53	1.22	1.20	5.50
		ML	1.80	.55	1.10	2.90
	Non-dominant	PC	4.06	1.75	2.10	8.50
		AP	3.02	2.06	1.40	7.70
		ML	2.01	.50	1.10	2.80

Close Eyes	Dominant	PC	5.76	1.25	4.00	8.80
		AP	4.44	1.23	2.60	6.80
		ML	2.76	.64	1.70	4.30
	Non-dominant	PC	5.67	1.50	3.30	9.40
		AP	4.54	1.27	2.30	7.60
		ML	2.49	.68	1.60	4.10

PC: Postural Control; AP: Anterior-Posterior; ML: Medio-Lateral. °: degree

Table 3. Correlation between active knee extension of dominant and non-dominant legs and postural control

	Test Conditions	**Variables**		**Active Knee Extension**	
				Dominant	**Non-dominant**
Open Eyes	Dominant	PC	r	.067	-.034
			p	.804	.902
		AP	r	-.024	.101
			p	.929	.710
		ML	r	.440	.121
			p	.088	.656
	Non-dominant	PC	r	.338	.213
			p	.201	.429
		AP	r	.365	.267
			p	.165	.318
		ML	r	-.422	-.257
			p	.104	.337
Close eyes	Dominant	PC	r	.102	.147
			p	.706	.587
		AP	r	-.090	-.072
			p	.740	.791
		ML	r	.180	.121
			p	.505	.654
	Non-dominant	PC	r	-.142	.036
			p	.599	.896
		AP	r	-.235	-.028
			p	.381	.917
		ML	r	.060	.118
			p	.826	.665

PC: Postural Control; AP: Anterior-Posterior; ML: Medium-Lateral

Table 3 elucidates the connection between the active knee extension angle of the dominant and non-dominant legs and postural control. Notably, no significant correlation emerged between the active knee extension of the dominant leg and the PC, AP, and ML values recorded under both EO and EC conditions ($p > 0.05$). Likewise, it was observed that the active knee extension of the non-dominant leg exhibited no significant association with the PC, AP, and ML values documented in both EO and EC scenarios ($p > 0.05$).

DISCUSSION

Our findings indicated no significant correlation between the active extension knee angles of the dominant and non-dominant legs and postural control. These outcomes suggest that isolated hamstring muscle shortening might not be a sole contributor to postural control disparities. However, it's crucial to acknowledge that further investigations are imperative to ensure the broad applicability of this finding and to verify its consistency across diverse athlete populations.

In light of our results, we posit that the link between active knee extension angles for the dominant and non-dominant legs and postural control could be constrained under specific circumstances. Furthermore, it's vital to underscore that the impact of hamstring muscle tightness on postural control could be influenced by various factors beyond whether the eyes are open or closed. These results underscore the necessity to comprehend the holistic effects of hamstring muscle shortness on postural control in football players, adopting a more comprehensive perspective.

The connection between hamstring tension and postural control remains somewhat unclear within the existing literature. The investigation by Shah et al. (Shah, 2013) delved into the correlation between hamstring and calf tension and the static and dynamic stability as well as balance in individuals aged 40 to 60 years. Noteworthy findings included significant positive and negative associations between hamstrings and calf tension and mobility, as assessed through measures like the Functional Reach Test, the Timed Up and Go test, and the Berg Balance Scale. This study underscores the intricate interplay between muscle tension and balance, underscoring the necessity of incorporating these variables into clinical evaluations and preventive strategies. These outcomes also suggest that a deeper exploration is required to comprehend the link between hamstring muscle tightness and postural control.

Diverging from earlier research, the present study's outcomes showcase that the connection between hamstring muscle flexibility and postural control is constrained. This discrepancy might be attributed to dissimilarities in sample demographics, measurement tools, or shifts in athlete populations. Hence, forthcoming research encompassing a broader and more varied participant pool could potentially furnish a more holistic understanding of these results.

In contrast to earlier studies, the findings from our present research indicate a constrained association between hamstring muscle flexibility and postural control. This variation could stem from disparities in sample choices, the tools used for measurement, or shifts in the demographics of athletes under consideration. As a result, upcoming investigations involving a broader and more diverse array of participants could offer deeper insights, allowing for a more comprehensive understanding of these outcomes.

Conversely, the literature also encompasses other studies that lend support to our research findings. For instance, Bakhtiary et al. (Bakhtiary et al., 2015) delved into the impact of hamstring muscle shortness on both dynamic and static balance within a cohort of young and healthy individuals. Their study outcomes revealed that hamstring muscle shortening yielded no noteworthy influence on either static or dynamic balance. This research stands out as a rare instance where the connection between hamstring muscle shortness and balance was scrutinized, specifically within a youthful population.

Similarly, Kuszewski et al. (Kuszewski et al., 2015), delved into the correlation between passive stiffness of hamstring muscles and the strategy employed for postural stability. The results of their investigation indicate that hamstring stiffness doesn't impinge upon the strategy used for postural control. Likewise, Martinez et al. (Encarnación-Martínez et al., 2023) embarked on an analysis of how hamstring length influences dynamic stability and agility. While their findings do highlight reduced range of motion in individuals with hamstring tightness, they emphasize that this condition doesn't manifest distinct effects on performance and dynamic stability, as demonstrated by tests centered around hamstring extensibility.

It's imperative to acknowledge the methodological limitations present in this study. The restricted sample size, comprised solely of male football players within a specific age range, may constrain the generalizability of findings to a broader demographic. Moreover, the cross-sectional design limits the establishment of causality, offering only a snapshot of the relationship between hamstring tension and postural control at a single point in time, hindering definitive cause-and-effect inferences. Longitudinal studies tracking changes over time would offer more nuanced insights. The study's controlled environment during assessments might not fully replicate real-game scenarios, potentially limiting the practical application of the findings, as factors like stress, fatigue, or varying playing conditions were not accounted for. Additionally, using subjective measures, such as the goniometer for knee extension, introduces potential measurement errors and subjectivity. Employing a combination of objective and standardized measurements could enhance reliability and accuracy.

The practical and clinical implications stemming from this study merit consideration. Specifically, for coaches and healthcare practitioners tasked with evaluating the

postural control of football players grappling with hamstring muscle tightness, relying solely on the angles of the dominant and non-dominant legs might prove insufficient. Consequently, there's a need for further investigation to deepen our comprehension of the intricate relationship between hamstring muscle shortening and postural control.

CONCLUSION

In summation, this study aimed to delve into the correlation between active knee extension angles and postural control among football players facing hamstring muscle tightness. The findings underscore the absence of a discernible connection between active extension knee angles of the dominant and non-dominant legs and postural control. Although the hypothesis of our study suggested a potential influence of increased hamstring tightness on the postural control abilities of footballers, our findings did not substantiate this hypothesis. The lack of a significant correlation between hamstring tightness and postural control abilities in our study challenges the validity of this initial hypothesis. There are many factors that influence postural control. Therefore, these results emphasize the need to understand the relationship between hamstring muscle tightness and postural control from a broader perspective. For coaches and football players, it's vital to recognize that while isolated hamstring muscle tightness may not significantly impact postural control according to this study, a holistic approach to physical conditioning remains crucial. Coaches can focus on comprehensive training programs that address not only hamstring flexibility but also overall muscle balance, strength, and proprioception. Incorporating exercises targeting core stability, lower limb strength, and proprioceptive training can contribute to better overall performance and injury prevention. Additionally, football players can benefit from personalized stretching routines and warm-up protocols that encompass multiple muscle groups, aiming for balanced flexibility across the body. Understanding the importance of diverse conditioning approaches beyond isolated muscle assessments can enhance players' on-field performance and reduce the risk of injuries. Nevertheless, it's vital to recognize that additional research, involving diverse participant groups, has the potential to enrich our understanding of this topic even further.

Author Contribution Rates

Design of Study: ÖÇ(%50), BSÜ(%50)

Data Acquisition: FK(%60), RG(%40)

Data Analysis: AA(%50), NE(%50)

Writing Up: ÖÇ(%40), BSÜ(%30), AA(%30)

Submission and Revision: ÖÇ(%40), BSÜ(%30), AA(%30)

REFERENCES

Afonso, J., Rocha-Rodrigues, S., Clemente, F. M., Aquino, M., Nikolaidis, P. T., Sarmento, H., Fílter, A., Olivares-Jabalera, J., & Ramirez-Campillo, R. (2021). The Hamstrings: Anatomic and physiologic variations and their potential relationships with injury risk. In Frontiers in Physiology (Vol. 12). doi: 10.3389/fphys.2021.694604.

Bakhtiary, A. H., Fatemy, E., Hedayati, R., Ghorbani, R., & Gillani, M. (2015). The relationship between hamstring muscle shortness and dynamic and static balances in young healthy individuals. Koomesh, 16(4), 536–543.

Barbosa, G. de M., Dantas, G. A. de F., Silva, B. R. da, Pinheiro, S. M., Santos, H. H. dos, & Vieira, W. H. de B. (2017). Intra-rater and inter-instrument reliability on range of movement of active knee extension. Motriz: Revista de Educação Física, 23(1), 53–59. doi: 10.1590/s1980-6574201700010008.

Bigoni, M., Turati, M., Gandolla, M., Augusti, C. A., Pedrocchi, A., La Torre, A., Piatti, M., & Gaddi, D. (2017). Balance in young male soccer players: dominant versus non-dominant leg. Sport Sciences for Health, 13(2). doi: 10.1007/s11332-016-0319-4.

Cachupe, W. J. C., Shifflett, B., Kahanov, L., & Wughalter, E. H. (2001). Reliability of Biodex Balance System Measures. Measurement in Physical Education and Exercise Science, 5(2), 97–108. doi: 10.1207/S15327841MPEE0502_3.

Cai, P., Liu, L., & Li, H. (2023). Dynamic and static stretching on hamstring flexibility and stiffness: A systematic review and meta-analysis. Heliyon, 9(8), e18795. doi: 10.1016/J.HELIYON.2023.E18795.

Diker, G., Struzik, A., Ön, S., & Zileli, R. (2022). The relationship between the hamstring-to-quadriceps ratio and jumping and sprinting abilities of young male soccer players. International Journal of Environmental Research and Public Health, 19(12), 7471. doi: 10.3390/ijerph19127471.

Encarnación-Martínez, A., García-Gallart, A., Pérez-Soriano, P., Catalá-Vilaplana, I., Rizo-Albero, J., & Sanchis-Sanchis, R. (2023). Effect of Hamstring Tightness and Fatigue on Dynamic Stability and Agility in Physically Active Young Men. Sensors, 23(3), 1633. doi: 10.3390/s23031633.

Hansberger, B. L., Loutsch, R., Hancock, C., Bonser, R., Zeigel, A., & Baker, R. T. (2019). Evaluating the relationship between clinical assessments of apparent hamstring tightness: a correlational analysis. International Journal of Sports Physical Therapy, 14(2), 253–263. doi: 10.26603/ijspt20190253.

Kocaoglu, Y., & Girgin, Y. (2023). Effects of foot preference on postural control in soccer players. Turkish Journal of Kinesiology, 9(1), 67–76. doi: 10.31459/turkjkin.1203374.

Kuszewski, M., Gnat, R., Sobota, G., & Myśliwiec, A. (2015). Influence of Passive Stiffness of Hamstrings on Postural Stability. Journal of Human Kinetics, 45(1), 49–57. doi: 10.1515/hukin-2015-0006.

Mandorino, M., J. Figueiredo, A., Gjaka, M., & Tessitore, A. (2023). Injury incidence and risk factors in youth soccer players: a systematic literature review. Part II: Intrinsic and extrinsic risk factors. Biology of Sport, 40(1), 27–49. doi: 10.5114/biolsport.2023.109962.

Mohammadi Nia Samakosh, H., Brito, J. P., Shojaedin, S. S., Hadadnezhad, M., & Oliveira, R. (2022). What Does Provide Better Effects on Balance, Strength, and Lower Extremity Muscle Function in Professional Male Soccer Players with Chronic Ankle Instability? Hopping or a Balance Plus Strength Intervention? A Randomized Control Study. Healthcare, 10(10), 1822. doi: 10.3390/healthcare10101822.

Pfirrmann, D., Herbst, M., Ingelfinger, P., Simon, P., & Tug, S. (2016). Analysis of Injury Incidences in Male Professional Adult and Elite Youth Soccer Players: A Systematic Review. Journal of Athletic Training, 51(5), 410–424. doi: 10.4085/1062-6050-51.6.03.

Shah, C. (2013). The effect of Hamstring and Calf Tightness on Static, Dynamic Balance and Mobility - A Correlation Study. Indian Journal of Physiotherapy and Occupational Therapy - An International Journal, 7(4), 17. doi: 10.5958/j.0973-5674.7.4.115.

Shukla, M., & Patel, P. (2021). Correlation of Hamstring Flexibility with Sitting Hours and Physical Activity among Physiotherapy Students. Journal of Pharmaceutical Research International. doi: 10.9734/jpri/2021/v33i40a32245.

Śliwowski, R., Marynowicz, J., Jadczak, Ł., Grygorowicz, M., Kalinowski, P., & Paillard, T. (2021). The relationships between knee extensors/ flexors strength and balance control in elite male soccer players. PeerJ, 9, e12461. doi: 10.7717/peerj.12461.

Stolen, T., Chamari, K., Castagna, C., & Wisloff, U. (2005). Physiology of Soccer. Sports Medicine, 35(6), 501–536. doi: 10.2165/00007256-200535060-00004.