



e-ISSN: 2717-9966

GAZİ UNIVERSITY
FACULTY OF SPORTS SCIENCES

Gazi

JOURNAL of
PHYSICAL EDUCATION
and
SPORTS SCIENCES

GAZİ JOURNAL OF PHYSICAL EDUCATION AND SPORTS SCIENCES

Volume: 30

Issue: 1

March 2025

GAZİ JOURNAL of PHYSICAL EDUCATION and SPORTS SCIENCES

GAZİ BEĐEN EĐİTİMİ ve SPOR BİLİMLERİ DERĐİSİ

2025, Volume 30, Issue 1

e-ISSN 2717-9966

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Gazi Journal of Physical Education and Sports Sciences (Gazi JPES) is a peer-reviewed journal published quarterly.
dergipark.org.tr/en/pub/gbesbd



Volume
Issue
March

XXX
1
2025

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Editor's Note

In January 1996, under the leadership of my esteemed supervisor, Prof. Dr. İbrahim YILDIRAN, the Gazi Journal of Physical Education and Sports Sciences embarked on its journey—not just as an academic publication but as a true school. A place that not only disseminates knowledge but also fosters inquiry, upholds academic integrity, and nurtures scientific thought. Over the years, our journal has played a vital role in shaping numerous academics, becoming a meeting point for those dedicated to learning, researching, and sharing.

As a student of this school, I joined this remarkable journey in January 2005, taking on my first official role. Alongside countless esteemed academics, we learned, created, shared, and grew together. Now, I embrace the great responsibility of stepping into the role of editor within this invaluable institution—a true privilege.

The greatest strength of scientific knowledge lies in the dedication and ethical rigor with which it is produced. At the Gazi Journal of Physical Education and Sports Sciences, we have always upheld academic integrity, critical thinking, and scientific ethics as our core values. Moving forward, we remain committed to enriching the field of sports sciences, staying at the forefront of developments, and making meaningful contributions with the same dedication and precision.

In this process, the support of our valued readers, reviewers, and authors is more important than ever. I firmly believe that as we continue this journey of learning and growth together, we will keep spreading the light of science.

I look forward to collaborating and advancing knowledge together in this new chapter.

Editorün Notu

1996 yılının Ocak ayında Değerli Hocam Prof. Dr. İbrahim Yıldırım'ın öncülüğünde yola çıkan Gazi Beden Eğitimi ve Spor Bilimleri Dergisi, yalnızca bir akademik yayın değil, aynı zamanda bir okul oldu. Bilgiyi aktaran, sorgulamayı teşvik eden, akademik ahlaki ve bilimsel düşüncüyü besleyen bir yuva... Dergimiz, yıllar içinde birçok akademisyenin yetişmesine katkıda bulundu; öğrenmeyi, araştırmayı ve paylaşmayı ilke edinen herkes için bir buluşma noktası oldu.

Ben de bu okulun bir öğrencisi olarak, 2005 yılının Ocak ayında ilk resmi görevimi alarak bu büyük yolculuğa dahil oldum. Sayısız değerli akademisyenle birlikte öğrendik, ürettik, paylaştık ve çoğaldık. Şimdi ise bu kıymetli okulda editörlük görevini devralmanın sorumluluğunu yaşıyorum. Ne mutlu!

Bilimsel bilginin en büyük gücü, etik ilkelerle yoğrulmuş bir emekle üretilmesidir. Gazi Beden Eğitimi ve Spor Bilimleri Dergisi olarak bizler, akademik dürüstlüğü, eleştirel düşüncüyü ve bilimsel etik kurallarını her zaman en önemli değerlerimiz olarak gördük. Önümüzdeki dönemde de aynı hassasiyetle, spor bilimleri alanına yenilik katmak, güncel gelişmeleri yakından takip etmek ve bu alana değerli katkılar sunmak için özveriyle çalışacağız.

Bu süreçte siz değerli okuyucularımızın, hakemlerimizin ve yazarlarımızın desteği her zamankinden daha kıymetli. Birlikte öğrendiğimiz, birlikte büyüdüğümüz bu yolda, bilimin ışığını yaymaya hep birlikte devam edeceğimize inanıyorum.

Yeni dönemde de birlikte üretmek dileğiyle...




Prof. Dr. Gülfem SEZEN BALÇIKANLI

Editor of Gazi JPESS

Running Symmetry in Professional Football: Are We Measuring What Matters?

Profesyonel Futbolda Koşu Simetrisi: Gerçekten Ne Düşündüğümüzü Ölçüyor muyuz?

Research Article / Araştırma Makalesi

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Received / Geliş Tarihi : 08.07.2024
Accepted / Kabul Tarihi : 19.03.2025
Published / Yayın Tarihi : 25.03.2025

Ethical Statement / Etik Bilgilendirme
This study was ethically approved by the decision of the Istanbul Esenyurt University Ethics Committee dated 11.07.2023 and numbered 2023/06-12.

DOI: 10.53434/gbesbd.1512611

Abstract

The aim of this study is to evaluate the relationship between running symmetry measured by GPS devices and the risk of injury and performance metrics among professional soccer players. A total of 18 professional football players from a club competing in the Turkish Super League participated in the research. Throughout the 2022-2023 season, running symmetry data of the players were recorded using a GPS system. Football players' running symmetry and performance metrics can be affected by training history, physical adaptation and cultural training differences. Whether there are differences in such parameters between local and foreign football players who have trained in different leagues and with different methodologies has also been included in the study. The study aims to evaluate not only whether running symmetry is a biomechanical parameter but also its effect on performance variables related to injury risk. Also, metrics such as total distance, high intensity running distance, high metabolic power distance, player load, accelerations and decelerations were also recorded throughout the season. Analysis of the data revealed significant differences in running symmetry among players. Statistical differences were found between defender and attacker and midfielder players in terms of player load values. Moreover, a positive correlation was observed between running symmetry and certain performance metrics, suggesting a potential link between running symmetry and sports performance. Consequently, running symmetry measured via GPS technology may serve as a valuable indicator for performance and injury risk among professional soccer players.

Keywords: Running symmetry, GPS, Performance, Injury, Football

Öz

Bu çalışmanın amacı, GPS cihazlarıyla ölçülen koşu simetrisi ile profesyonel futbolcuların yaralanma riski ve performans metrikleri arasındaki ilişkiyi değerlendirmektir. Türkiye Süper Liginde mücadele eden kulüpten 18 profesyonel futbolcu araştırmaya katılmıştır. 2022-2023 sezonu boyunca GPS sistemi yardımıyla futbolcuların koşu simetrisi verileri kaydedilmiştir. Ayrıca toplam mesafe, yüksek şiddetli koşu mesafesi, yüksek metabolik güç mesafesi, oyuncu yükü, ivmelenme ve yavaşlama gibi performans metrikleri de tüm sezon boyunca kaydedilmiştir. Futbolcuların koşu simetrisi ve performans metrikleri, antrenman geçmişi, fiziksel adaptasyon ve kültürel antrenman farklılıklarından etkilenebilir. Özellikle farklı liglerde yetişmiş, farklı metodolojilerle antrenman yapmış olan yerli ve yabancı futbolcular arasında bu tür parametrelerde farklılıklar olup olmadığı da araştırmaya dahil edilmiştir. Araştırmada koşu simetrisinin yalnızca bir biyomekanik parametre olup olmadığını değil, aynı zamanda sakatlık riski ile ilişkili performans değişkenleri üzerindeki etkisini de değerlendirmeyi amaçlamaktadır. Yapılan analiz sonuçları, oyuncular arasında koşu simetrisinde belirgin farklılıklar olduğunu ortaya koymuştur. Savunma oyuncularıyla oyuncu yükü değerleri açısından hücum ve orta saha oyuncuları arasında istatistiksel olarak anlamlı fark olduğu bulunmuştur. Ayrıca, koşu simetrisi ile belirli performans metrikleri arasında pozitif bir korelasyon gözlemlenmiştir. Bu durum koşu simetrisi ile spor performansı arasında potansiyel bir bağlantı olduğunu göstermektedir. Sonuç olarak, GPS teknolojisiyle ölçülen koşu simetrisinin, profesyonel futbolcularda performans ve sakatlık riski için değerli bir gösterge olarak hizmet edebileceğini öne sürmektedir.

Anahtar Kelimeler: Koşu simetrisi, GPS, Performans, Yaralanma, Futbol

Introduction

In the sports industry, especially in football, technological advancements and analytical programs have led to a situation where more quantitative data can be collected and analyzed daily, as noted by sports science researchers (Millington & Millington, 2014). At the same time, we are currently in a period where professional athletes rank among the top earners in society, with contracts signed with players based on the expectation of their contributions to team success and shared objectives with their clubs. For example, Cristiano Ronaldo was reported to have earned approximately fifty-three million dollars in the 2015-2016 season, over which he played forty-eight matches for Real Madrid FC, earning over \$1 million per match and underscoring the substantial value athletes can bring to an organization (Saba, 2016).

Injuries suffered by footballers, or similar circumstances, can result in significantly less contribution to their teams, contrary to the club's expectations at the start of the season. To illustrate the financial impact of athletes' injuries on clubs, a detailed analysis can be performed using the example of the English player Wayne Rooney. This analysis is conducted by calculating the cost of the matches missed during the player's injury by multiplying these by his weekly wage. According to Transfermarkt (2024), if it is assumed that Rooney experienced injuries intermittently for 3 months over a period of 9 months, missing 36% of the matches during this time, and if it is considered that Rooney was earning two hundred fifty thousand pounds per week, then the player has the cost £7.5 million approximately to the club for this period. Therefore, it can be understood that Manchester United has paid either two point seven million pounds or 36% of seven point five million pounds to an athlete who could not perform physically during the injury period. Luke Shaw, earning seventy thousand pounds a week, missed 7 months in other words 86% of the same 9-month period due to injuries, costing the club approximately £1.8 million (Saba, 2016). The examples provided illustrate how injuries can impact more than just the matches lost, particularly in the case of players with higher salaries. The financial implications of injuries extend beyond mere lost matches for clubs, encompassing other significant expenditures such as medical care, rehabilitation costs, decreased ticket sales, and funding for potential end-of-season activities.

After injuries in football, if surgery is required during the recovery process, athletes must then undergo a comprehensive rehabilitation program (Mangine, Minning, Eifert-Mangine, Colosimo & Donlin, 2008). Experts adding alternative treatments like cryotherapy often incur additional costs for clubs, especially when using external resources, for athletes who are unable to contribute their physical performance skills to their club. The key to maximizing the 'profit' that can be obtained from players is to closely monitor their performance in training or matches, regularly adjust training programs to maximize

benefits from the player or focus on minimizing the time spent away from the field/team by emphasizing a quick rehabilitation period post-injury. If the rehabilitation process is rushed, proper recovery and return to the field may not occur, potentially leading to the development of new injuries. The extra time spent in returning players to the field can result in the inability to implement physical performance (Schmitt, Tim & McHugh, 2012). When considering wearable technologies in football, Global Positioning Systems (GPS) and related equipment can accurately and reliably collect quantitative variables such as total distance, high intensity running, sprint distances, or the impact on the ground during training and matches, thus analyzing players' physical performance (Kelly, Coughlan, Green & Caulfield, 2012; Montgomery, Pyne & Minahan, 2010). Wearable GPS devices are becoming increasingly popular among top sports teams such as the English Premier League, NFL, and NBA (Aoki et al., 2017). These technological advancements allow coaches to gather a comprehensive dataset exceeding 100 variables, encompassing both internal and external load parameters, daily.

GPS technologies have great importance and potential within sports sciences and coaching practices. Devices such as accelerometers, gyroscopes, heart rate monitors, and GPS systems enable the collection of critical variables for assessing training load. These variables include objective measurements necessary for evaluating athletes' performance, such as speed, heart rate, total distance covered, high intensity running distance, sprint distance, ground reaction force, running or walking symmetry, and body load. Particularly, data of walking and running symmetry obtained through GPS technology help coaches and sports scientists to make training plans and injury prevention strategies more consciously by determining symmetric and asymmetric differences in left and right walking/running patterns. The symmetry of walking/running derived from these systems is defined by equal measurements of variables such as acceleration/deceleration and ground reaction forces on both sides (Kim & Lee 2013; Staab et al., 2014; Vogt, Banzer, Bayer, Schmidtleicher & Kerschbaumer, 2006). When the maximum forces exerted on the ground are the same during right and left foot impacts, they are labelled as "symmetric", whereas variations in these forces are termed "asymmetric". The measurement and tracking of running symmetry in team sports are an area that is still developing but are considered important (Kenneally-Dabrowski, Serpell & Spratford, 2017). The symmetry index offers a way to quantitatively measure this balance between the right and left sides, allowing for the percentage difference between left and right walking/running data to be measured; where a zero (0) value indicates perfect symmetry, and values below or above zero indicate asymmetry. Consequently, higher scores emphasize the presence of greater asymmetry in an athlete (Carpes, Mota & Faria 2010; Robinson, Herzog & Nigg, 1987). Brughelli, Cronin, Mendiguchia, Kinsella & Nosaka, (2010) have reported that athletes who have previously

suffered hamstring injuries show greater asymmetry in the horizontal component of ground reaction force during sub-maximal running compared to those who have not. Therefore, the detection of asymmetric differences during walking and running is crucial for the continuous maintenance of athlete health and performance (Kenneally-Dabrowski et al., 2017).

This research focuses on the relationship between walking/running symmetry data obtained from GPS devices used in assessing the training load of professional football players and the risk of injury. The second aim of the study is to investigate the impact of running symmetry data collected during official competitions and training sessions throughout the season on the risk of injury occurrence in professional football players. Considering this data, the study aims to contribute to the more effective and safe organization of training programs, return-to-play practices after injuries, and preventive performance monitoring.

Method

Research Model

The study utilized the descriptive survey model, a method commonly used in research to provide a detailed and thorough analysis of a situation. The study utilizes both retrospective and relational survey models.

Research Group

In this context, the sample of the research includes professional football players competing in the top category of a football club in the Turkish Super League during the 2022-2023 season. The professional football players included in this study ($n=18$) were selected from the same football club. All participants (age= 27.2 ± 6.3 years, height= 184.0 ± 7.3 cm, body weight= 81.0 ± 8.5 kg and body fat percentage= $5.3 \pm 1.6\%$) were thoroughly informed both orally and in writing before the commencement of the study and signed voluntary consent forms.

Data Collection Tools

Performance and running symmetry data from the participants were collected using a GPS system (Vector S7; Catapult Sports, Melbourne, Australia) throughout the 2022-2023 Turkish Super League season. The injury data was collected for a period of 1 month (4 weeks) prior to the player's injury, using a GPS system (Catapult Vector S7, Catapult Sports, Melbourne, Australia). Only non-contact injuries were included in the analysis. The injuries were not grouped by specific muscle or joint types, as this was not the focus of the study. The importance of research is to evaluate the relationship between running symmetry and injury occurrence. Running symmetry efforts are only calculated if they meet the set minimum velocity and minimum consecutive footstrike thresholds that have been set in the OpenField cloud. For a Running Symmetry Effort to be calculated, the velocity must exceed the minimum velocity for all footstrikes, and the

amount of consecutive Footstrikes in the effort must be above the minimum consecutive footstrike threshold. For example, a running symmetry effort will be calculated if a device detects 8 or more consecutive Footstrikes, where the Velocity is over 3.3m/s during each footstrike. (Default thresholds of 3.3m/s and 8 consecutive footstrikes) (Tacca et al., 2022). Data from the load tracking of all field and fitness (gym) training sessions of the participants during the specified season are included. Research has shown that 10-Hz GPS devices are both valid and reliable for measuring distance and speed (Crang et al., 2022; Scott, Black, Quinn & Coutts, 2013). These devices were placed in specially designed pockets. These pockets are located at the midpoint of the participants' scapula bones on the back of specially made athletic vests. The vests' dimensions are 81mm in length, 43.5mm in width, and they weigh 53 grams. Throughout the season, athletes consistently used these devices. This consistent use was to minimize potential measurement errors (Asian-Clemente, Rabano-Muñoz, Requena, Santalla & Suárez-Arrones, 2022). The GPS trackers were turned on 15 minutes prior to every game and practice to guarantee good satellite connection and accurate data (Duffield, Reid, Baker & Spratford, 2010). The data obtained during the study were regularly transferred to Microsoft Excel for analysis after training sessions and matches, with necessary checks performed to remove any incomplete or erroneous data from the research scope.

In the study, the performance and running asymmetry data collected from participants were analyzed based on the following parameters provided by the GPS system: total distance covered, distance covered per minute, high-intensity running distance between speeds of 20-25 km/h, sprint distance at speeds greater than 25 km/h, maximum speed, player load, high metabolic power distance, acceleration and deceleration distance at $>2 \text{ m}\cdot\text{s}^{-2}$ (ACC-DEC_{distance}), total number of accelerations and decelerations (ACC-DEC_{number}), and running asymmetry.

Data Analysis

In the phase of data evaluation, data was arranged using Microsoft Excel 2003, and statistical analyses were carried out using SPSS version 23 software. The Shapiro-Wilk test was utilized to ascertain if the data displayed a normal distribution. After the normality assessment, when the data was normally distributed, comparisons were made using the independent samples t-test at a significance level of $\alpha=0.05$. The one-way ANOVA test was utilized to analysis three or more groups comparison. In correlation analysis, a correlation coefficient (r) below 0.50 suggests a weak correlation, while a coefficient between 0.50 and 0.70 indicates a moderate correlation, and a coefficient above 0.70 indicates a strong relationship (Durmuş, Yurtkoru & Çinko, 2013).

Ethical Statement

The research was conducted following the approval from the Ethics Committee of Istanbul Esenyurt University, dated 11/07/2023, with approval number E-12483425-299-32889.

Findings

This section presents the findings of the analyses conducted to examine performance-related variables in the context of injury

duration, player positions, and running asymmetry among professional football players competing in the Turkish Super League during the 2022–2023 season. Comparative analyses were performed using one-way ANOVA to identify differences in physical performance metrics across player positions and varying durations of injury. Additionally, Pearson product-moment correlation analysis was utilized to investigate the relationships between running asymmetry and other performance parameters.

Table 1. Descriptive and comparative data by player position in Turkish Super League (2022-2023)

Variables	Positions	N	Mean	Sd	f	p	Group differences
Duration (minute)	Defense	108	61.944	19.9817	1.980	.140	
	Midfielder	186	57.694	20.8381			
	Attacker	22	63.727	18.1244			
Total Distance per minute (m)	Defense	108	59.7776	31.25357	.385	.681	
	Midfielder	186	57.0060	36.00345			
	Attacker	22	62.1409	22.35480			
High intensity running distance (m)	Defense	108	181.898	264.0748	.609	.544	
	Midfielder	186	186.306	251.0865			
	Attacker	22	124.409	122.9079			
Sprint distance (m)	Defense	108	25.296	42.9499	.809	.446	
	Midfielder	186	32.134	49.8573			
	Attacker	22	34.364	48.9115			
Total distance (m)	Defense	108	4917.056	2696.7925	2.182	.114	
	Midfielder	186	4447.333	2391.9270			
	Attacker	22	3877.091	1608.4614			
Maximum velocity (km/h)	Defense	108	26.5734	22.55457	.058	.944	
	Midfielder	186	26.6025	17.29713			
	Attacker	22	25.1818	3.94771			
Player load (a.u.)	Defense	108	555.491	295.6559	4.126	.017*	1>2>3 p=0.017
	Midfielder	186	477.468	233.2858			
	Attacker	22	431.727	176.1039			
High metabolic power distance (m)	Defense	108	572.324	456.5746	.347	.707	
	Midfielder	186	567.134	494.7507			
	Attacker	22	656.318	415.8615			
ACC-DEC distance (m)	Defense	108	318.426	252.7247	1.877	.155	
	Midfielder	186	271.699	193.3069			
	Attacker	22	256.818	145.7658			
ACC-DEC (number)	Defense	108	265.278	129.0021	1.802	.167	
	Midfielder	186	234.500	139.0493			
	Attacker	22	240.909	120.6695			
Running Asymmetry (%)	Defense	108	2.5278	2.29774	1.772	.172	
	Midfielder	186	2.8383	2.93099			
	Attacker	22	3.6818	2.03274			

* $p < 0.05$

Upon examining Table 1, a statistically significant difference was found in the player load values of football players competing in the 2022-2023 season in relation to the positions they played ($p < 0.05$).

The Bonferroni post-hoc test was conducted to identify between which positions the difference occurred. The analysis indicated that the average load on defenders was significantly higher compared to that on midfielders and forwards.

Table 2. Comparative analysis based on the duration of injury in Turkish Super League (2022-2023 season)

Variables	Duration of Injury (Days)	N	Mean	Sd	f	p	Group differences
Duration (minute)	1 or less	123	60.000	25.0177	.065	.937	
	1.01 – 4	115	59.565	16.8675			
	More than 4	77	58.922	17.2960			
Total Distance per minute (m)	1 or less	123	42.0121	38.10412	28.348	.000*	3>2>1 p=0.000
	1.01 – 4	115	66.7960	26.34628			
	More than 4	77	71.6697	24.25934			
High intensity running distance (m)	1 or less	123	268.171	342.7880	13.343	.000*	1>2>3 p=0.000
	1.01 – 4	115	128.513	140.5466			
	More than 4	77	120.247	134.0851			
Sprint distance (m)	1 or less	123	40.650	54.8971	5.273	.006*	1>3>2 p=0.006
	1.01 – 4	115	21.887	41.1181			
	More than 4	77	25.299	40.8154			
Total distance (m)	1 or less	123	5210.024	3396.0547	6.998	.001*	1>2>3 p=0.001
	1.01 – 4	115	4186.122	1530.3679			
	More than 4	77	4129.818	1448.4117			
Maximum velocity (km/h)	1 or less	123	25.4074	4.93166	.528	.590	
	1.01 – 4	115	26.5478	21.73535			
	More than 4	77	28.2064	26.39152			
Player load (a.u.)	1 or less	123	568.179	353.7686	7.192	.001*	1>2>3 p=0.001
	1.01 – 4	115	459.843	149.7850			
	More than 4	77	455.714	156.6194			
High metabolic power distance (m)	1 or less	123	358.415	451.9375	24.045	.000*	2>3>1 p=0.000
	1.01 – 4	115	715.209	455.0163			
	More than 4	77	714.455	418.2634			
ACC-DEC distance (m)	1 or less	123	336.447	287.1197	5.732	.004*	1>2>3 p=0.004
	1.01 – 4	115	261.504	132.6737			
	More than 4	77	245.364	153.3344			
ACC-DEC (number)	1 or less	123	221.797	130.9658	3.309	.038*	2>3>1 p=0.038
	1.01 – 4	115	265.339	131.2095			
	More than 4	77	253.234	142.9788			

* $p < 0.05$

Upon examining Table 2, a statistically significant difference was observed in the scores of distance covered per minute (m), high-intensity running distance, sprint distance, total distance, player load, high metabolic power distance, ACC-DEC_{distance}, and ACC-DEC_{number} in relation to the duration until injury among football players competing in the 2022-2023 season ($p < 0.05$).

The Bonferroni post-hoc test analysis was applied to determine between which durations these differences occurred. It was found that as the duration until injury decreased, the distance covered per minute also decreased, and as it increased, the values for high-intensity running distance, total distance, Player Load, and ACC-DEC_{distance} also decreased. For other parameters such as sprint distance, high metabolic power

distance, and ACC-DEC_{number} ($> 2 \text{ m} \cdot \text{s}^{-2}$), the running asymmetry value for durations “1.01 – 4” was observed to increase more compared to durations “More than 4” and “1 or less”.

Upon examining Table 3 and analyzing the Pearson Product-Moment Correlation to determine the relationship between running asymmetry values and various parameters, no significant relationship was observed between the duration until injury and maximum speed (km/h). However, a significant negative correlation was found with duration and distance covered per minute, whereas a significant positive correlation was observed with high-intensity running distance, sprint distance, total distance, player load, high metabolic power distance, ACC-DEC_{distance}, and ACC-DEC_{number} ($p < 0.05$).

Table 3. Pearson Product-Moment Correlation analysis between running asymmetry and all parameters

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1 Duration of injury	1											
2 Duration	0.094	1										
3 Total distance per minute	0.028	-.203*	1									
4 High intensity running distance	0.011	.349*	-.436*	1								
5 Sprint distance	0.054	.183*	-.296*	.709*	1							
6 Total distance	0.036	.722*	-.260*	.754*	.492*	1						
7 Maximum velocity	-0.013	-0.016	0.039	.169*	0.096	0.069	1					
8 Player load	0.061	.734*	-.267*	.734*	.493*	.958*	0.054	1				
9 High metabolic power distance	0.071	.163*	.752*	-.179*	-0.082	0.063	0.108	0.06	1			
10 ACC-DEC (distance)	0.076	.621*	-.301*	.704*	.513*	.838*	0.11	.868*	.124*	1		
11 ACC-DEC (number)	0.071	.566*	.301*	0.098	0.09	.511*	0.049	.548*	.693*	.601*	1	
12 Running Asymmetry	0.039	-0.056	.319*	-.259*	-.149*	-.206*	0.055	-.204*	.253*	-.199*	0.07	1

* $p < 0.05$

Discussion

The purpose of this study is to examine the effects of running symmetry data, collected during official matches and training sessions throughout the season, on the risk of injury occurrence in professional football players. Running asymmetry is considered to have significant effects on athletic performance and injury risk. Research indicates that addressing inter-limb asymmetries through targeted interventions can enhance physical performance and reduce the risk of injuries in athletes (Pardos-Mainer, Bishop & Gonzalo-Skok, 2020). In a similar study, researchers linked observed walking asymmetry during high-intensity track runs to a history of injuries, arguing that monitoring and addressing asymmetry is crucial for injury prevention and performance optimization (Gilgen-Ammann, Taube & Wyss, 2017).

The data presented in Table 2 show the relationships between injury duration and certain performance variables. However, although the running asymmetry was not directly included in the table, the relationship between running asymmetry and injury duration was evaluated in the distribution analyses performed with the relevant variables. The findings suggest that the increase in running asymmetry continues, especially with high metabolic power distribution and acceleration/deceleration progression. This situation suggests that running asymmetry may be indirectly related to injury duration. Although there were significant differences in the loading parameters of the players in different positions in the study, no significant change was observed in running asymmetry values. This situation may be related to the individual movement mechanics and adaptation processes of the players. Especially in high-level football players, a certain running symmetry can be maintained thanks to repeated training and motor learning processes, and this may cause position-based load differences not to be directly reflected in running asymmetry. In addition, it is thought that the relationship between loading parameters and running asymmetry may vary depending on individual biomechanical

and neuromuscular factors rather than being linear. "Future studies could be expanded to include factors such as individual movement strategies and musculoskeletal adaptations to better understand the relationship between player load and running asymmetry.

In this study conducted on professional football players in the Turkish Super League, significant positional differences have been observed (Table 2). Analyzing the values associated with different positions, the player loads were as follows: defenders ($n=108$, average=555.491, $Sd=295.6559$), midfielders ($n=186$, average=477.468, $Sd=233.2858$), and forwards ($n=22$, average=431.727, $Sd=176.1039$). Statistical analysis has revealed significant differences in Player Load between these positions ($p=0.017$), with defenders bearing a significantly higher average load compared to midfielders and forwards. The research findings suggest that the higher statistical load on defenders, compared to other positions in terms of Player Load, is likely due to the distinct roles and responsibilities on the field. Especially considering the dimensions of the football field, it has been observed through studies that the duties and responsibilities of each position demand different physical requirements (Castillo-Rodríguez, Durán-Salas, Giménez, Onetti-Onetti & Suárez-Arrones, 2023; Gimenez, Castellano, Lipińska, Zasada & Gómez, 2020). The significantly higher player loads on defenders reflect the intensity and continuity of the defensive roles they undertake during games. Defenders are typically engaged in direct confrontation with the opposing team's attackers, placing them in positions that require high-intensity physical activity continuously. This scenario leads to frequent and high-speed changes in direction, contributing to the increase in player load due to actions required by their defensive tasks.

The relationship between football players' injury durations and their physical performances is complex and multifaceted. Research has observed that professional football players

experience greater declines in performance levels after injuries compared to controls, suggesting a potential link between the duration of injury and physical performance (Ross, Savage-El-liott, Brown & Mulcahey, 2020). Similar findings have been observed in our study (Table 2), where it was found that as the duration of injury decreased, the values for distance covered per minute (m) also decreased, and as the duration increased, high-intensity running distance (m), total distance (m), Player Load, and ACC-DEC_{distance} ($>2 \text{ m}\cdot\text{s}^{-2}$) values also decreased. Similar results have been reported by Carey, Huffman, Parekh & Sennett, (2006) where researchers noted a one-third reduction in performance of injured players upon their return to matches. This indicates that injuries can have a significant impact on athletes' performance when they return to the field (Carey et al., 2006).

When examining the statistical analysis results (Table 3), although no significant relationship was observed between the duration until injury and Maximum Speed (km/h), a positive correlation was found between the duration until injury and both high intensities running distance and sprint distance parameters. Previous studies, such as those by Vial, Cochrane Wilkie, Turner & Blazeovich, (2023) suggest that fatigue levels can influence extremity asymmetries during sprints; sprints performed without fatigue prioritize speed, while those performed with fatigue may prioritize reducing injury risk (Vial et al., 2023). However, other studies, differing from these results, have also examined the relationship between kinematic step cycle asymmetry and sprint performance, and Haugen, Danielsen, McGhie, Sandbakk & Ettema, (2017) found that asymmetry in athletic sprinters does not have an impact on sprint performance or injury rates. Conversely, when looking at the speeds rather than sprint distances of professional footballers, research by Mikel et al., (2021) highlights that the gender of athletes and running speed do not significantly affect asymmetry. These results are consistent with the outcomes of our investigation (V_{\max} (km/h) $p=0.069$). Furthermore, thresholds of asymmetry that could negatively impact directional change performance in athletes have been identified, emphasizing that assessing and addressing asymmetry is crucial to prevent declines in performance (Philipp, Garver, Crawford, Davis & Hair, 2020). Running asymmetry can potentially affect a footballer's speed, agility, and overall biomechanical efficiency, or their ability to perform optimally on the field. Additionally, running asymmetry can predispose football players to various lower extremity injuries, such as hamstring or quadriceps strains, ACL tears, and ankle sprains, which can have significant consequences for their careers.

In football injuries, especially those involving the quadriceps muscles, impairments in joint range of motion (ROM) and strength are associated with disruptions in running symmetry (Chmielewski, Rudolph, Fitzgerald, Axe & Snyder-Mackler, 2001; Shelbourne & Klotz, 2006). Research shows that performance or strength coaches can effectively use unilateral

strength training programs tailored to athletes to reduce asymmetry and enhance their performance (Chen, Yi & Tian, 2023). However, depending on the context of the asymmetry, it can have both positive and negative effects. While asymmetry in upper extremity movements can enhance physical performance, it may also increase the risk of injuries in sports involving walking/running (Gao et al., 2022). Additionally, research indicates that inter-leg strength asymmetry is associated with both performance and injury risk in adolescent long-distance runners, emphasizing the need to address and understand asymmetry in this population (Blagrove, Bishop, Howatson & Hayes, 2020). Consequently, running asymmetry can have multifaceted effects on athletic performance and injury risk. While a certain degree of asymmetry can be beneficial in specific contexts, excessive or unaddressed asymmetry can lead to increased injury risk and decreased performance. Therefore, understanding individual asymmetry profiles and implementing targeted interventions to manage asymmetry are crucial for optimizing athletic performance and reducing injury risk. As running symmetry varies greatly among individuals, comparing an individual's symmetry to their own baseline data provides a more robust prediction than comparing it to the team average or assuming perfect symmetry for everyone.

Conclusion

In conclusion, although the value of running asymmetry may not contain statistically significant differences, it is observed that players' running asymmetry values increase when transitioning from defense to attack based on the average data. In football injuries, the duration players are side-lined can lead to substantial financial burdens for clubs due to salaries paid and the lack of corresponding physical performance and skills utilization. Therefore, in the sports world, especially in football, various methods are employed to accurately predict injuries that arise from non-contact or the effects of training load on the player. Our study aimed to demonstrate the applicability of the "Running Asymmetry" parameter within the GPS system, i.e., running symmetry, and the results are expected to provide a different perspective to coaches, performance trainers, physiotherapists, and other stakeholders in football.

Considering the negative financial impact of injuries in football and their detrimental effect on players' careers, monitoring training load and predicting injury onset using the running asymmetry parameter could be an important method. Understanding the relationship between injury timing and physical parameters, including in professional footballers, and optimizing running symmetry could be crucial for enhancing performance and minimizing the probability of injury. Although the results may not be statistically definitive, the positive correlations identified in practical applications suggest that this study could pioneer greater emphasis on the value of running asymmetry. Further detailed outcomes could emerge from analyzing

larger research groups, including different age groups, in studies conducted before and after injuries.

Based on the findings of the present study, several recommendations are proposed to guide future research and practical applications: Firstly, although running asymmetry appears to be a promising parameter for monitoring player injuries, current evidence remains inconclusive. More comprehensive datasets and a standardized approach that integrates multiple parameters are necessary to draw definitive conclusions regarding its diagnostic value.

Secondly, the observed positive associations between running asymmetry and high-intensity running, sprint distance, and acceleration-deceleration metrics highlight the relevance of this variable in injury monitoring. Future studies should consider combining running asymmetry with additional biomechanical and physiological parameters not examined in the present study to enhance predictive accuracy.

Thirdly, further efforts should be directed towards improving the precision and validity of data derived from running asymmetry. Comparing this parameter with more detailed and extensive injury datasets could yield a clearer understanding of its sensitivity and specificity.

Additionally, considering the limited number of studies focusing on running asymmetry, especially within football, it is recommended that future research explore its relationship with injuries across various age groups and both male and female athletes. Such demographic analyses may offer valuable insights into population-specific injury patterns and risk factors. Moreover, a comparative analysis involving different GPS-based tracking systems could be beneficial in assessing the reliability and consistency of running asymmetry and training load measurements. This approach would contribute to the development of more robust monitoring strategies.

Finally, to provide more actionable insights for coaches, performance staff, and rehabilitation professionals, longitudinal studies incorporating multi-seasonal and multi-team data are encouraged. This broader scope could support the formulation of more effective training, recovery, and injury prevention strategies.

Financial Support

No financial support was received from institutions and/or institutions during the preparation and writing of this study.

Conflict of Interest

There is no conflict of interest between the authors regarding the publication of this article.

Author Contribution

Research Idea: ST; Research Design: ST and TK; Data Analysis: OA and TK; Writing: ST and OA; Critical Examination: ST

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The Mediating Role of Emotional States in the Relationship Between Self-Efficacy and Athletic Performance of Young Female Athletes

Genç Kadın Sporcular Arasında Öz Yeterlilik ile Atletik Performans Arasındaki İlişkide Duygusal Durumların Aracı Rolü

Research Article / Araştırma Makalesi

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Received / Geliş Tarihi : 07.01.2025
Accepted / Kabul Tarihi : 20.03.2025
Published / Yayın Tarihi : 25.03.2025

Ethical Statement / Etik Bilgilendirme
This study was approved by the Ethics Committee of Batman University on 09.07.2024 with the decision number 167570.

DOI: 10.53434/gbesbd.1615358

Abstract

This study examines the mediating role of emotional states in the relationship between self-efficacy and athletic performance among young female athletes. Self-efficacy, defined as the belief in one's ability to succeed in specific situations, has been shown to influence athletic performance. Emotional states, both positive and negative, can significantly impact athletes' cognitive and physical functioning, thus affecting performance outcomes. The research sample consisted of 339 young female athletes from various university teams in Turkey. Data were collected using validated scales for self-efficacy, emotional states, and individual performance assessment. Path analysis revealed that self-efficacy positively influences athletic performance directly and indirectly through positive emotional states. Specifically, higher self-efficacy was associated with increased positive emotions, which in turn improved performance. Negative emotions, however, did not mediate the relationship between self-efficacy and performance. These findings suggest that fostering self-efficacy and positive emotional experiences can enhance athletic performance in young female athletes. Future studies should explore the role of emotion regulation strategies in mitigating the effects of negative emotions on performance.

Keywords: Self-efficacy, Athletic performance, Emotional states, Young female athletes

Öz

Bu çalışma, genç kadın sporcular arasında öz yeterlilik ile atletik performans arasındaki ilişkide duygusal durumların aracı rolünü incelemektedir. Öz yeterlilik, kişinin belirli durumlarda başarılı olabileceğine dair inancı olarak tanımlanır ve bu çalışmada atletik performansı hem doğrudan hem de olumlu duygu durumları aracılığıyla dolaylı olarak olumlu yönde etkilediği bulunmuştur. Olumlu ve olumsuz duygusal durumlar, sporcuların bilişsel ve fiziksel işlevlerini önemli ölçüde etkileyebilir ve bu durum performans sonuçlarında belirgin farklılıklara yol açabilir. Araştırma örneklemini, Türkiye'deki çeşitli üniversite takımlarından 339 genç kadın sporcudan oluşmaktadır. Araştırma verileri, öz yeterlilik, duygu durumları ve bireysel performans değerlendirmesini ölçmek için onaylanmış ölçekler kullanılarak elde edilmiştir. Yapılan yol analizi, öz yeterliliğin atletik performansı hem doğrudan hem de olumlu duygu durumları aracılığıyla dolaylı olarak olumlu yönde etkilediğini ortaya koymuştur. Spesifik olarak, daha yüksek öz yeterlilik, artan olumlu duygularla ilişkilendirilmiş ve bu da performansı artırmıştır. Öte yandan, olumsuz duyguların öz yeterlilik ve performans arasındaki ilişkiye aracılık etmediği görülmüştür. Bu bulgular, öz yeterliliğin ve olumlu duygusal deneyimlerin teşvik edilmesinin genç kadın sporcularda atletik performansı artırabileceğini göstermektedir. Gelecekteki çalışmalar, olumsuz duyguların performans üzerindeki etkilerini azaltmada duygu düzenleme stratejilerinin rolünü araştırmalıdır.

Anahtar Kelimeler: Öz yeterlilik, Atletik performans, Duygu durumları, Genç kadın sporcular

Introduction

In this study, the potential mediating role of emotional states in the relationship between self-efficacy and athletic performance among young female athletes will be examined. Because of positive and negative experiences in the sports environment on athletic performance, self-efficacy is one of the key variables that must be analyzed from a psychological perspective (Molina et al., 2018). In his study, Bandura, (1997) emphasized that the concept of self-efficacy has a profound impact on an individual's learning, motivation, and performance. Self-efficacy is defined as an individual's perception, belief, and judgment regarding their ability and capacity to cope with different situations and to succeed in specific activities (Senemoğlu, 2003). A high level of self-efficacy is crucial for individuals as it enables them to adopt a more courageous attitude in analyzing situations and to confront challenges with stronger conviction (Kocaekşi & Yıldırım, 2020). Individuals with low self-efficacy typically exhibit hesitant behaviors when faced with challenging tasks, perceiving them as threats. Due to a loss of belief in their own abilities, they are unable to demonstrate the required performance (Ritter et al., 2001). It has been observed that individuals with high self-efficacy have a lower likelihood of experiencing failure in sports and, even if they do encounter failure, they persist without giving up (Güvendi & Demir, 2019).

Emotion is identified as an important concept that aids an athlete in focusing and striving for success in the face of competition (Posner & Eiler, 2013; Vallerand et al., 2003). Since emotions also affect athletes' cognitive, physical, and motivational states, emotional states become even more prominent in sports (Jones, 2003; 2012). Both in scientific research and within socio-cultural contexts, women are often observed to approach situations with more emotionality than men (Chapman et al., 2007; DePretis et al., 2021; Knights & Surman, 2008). When reviewing the literature, it is found that women exhibit a lower emotional balance (Chapman et al., 2007; Schmitt et al., 2008), with a higher prevalence of depression and a greater likelihood of experiencing lifetime stress disorders compared to men. Furthermore, anxiety disorders are 2.25 times more common in female than in male (Bekker & Van Mens-Verhulst, 2007). Various studies have shown that mood disorders in women occur at least twice as frequently as in men (Kessler, 2003; Lewinsohn et al., 1998; Steiner et al., 2003; Wittchen & Jacobi, 2005). Considering that the athletes in our sample consist of young women and that their emotional states may remain unstable after adolescence (Dilip et al., 2010), conducting such studies will contribute to the field of sports psychology and fill an important gap in the literature.

The importance of athletic performance is indispensable for athletes in achieving success in their careers and reaching their long-term goals. Athletic performance is defined as the

entirety of efforts made to successfully complete an athletic task (Bayraktar & Kurtoğlu, 2004). To accurately assess athletes' performance, it is crucial to consider all factors that affect performance (Bayraktar & Kurtoğlu, 2009). Athletes' performance is shaped by their technical, tactical, psychological, and physical attributes (Michalsik et al., 2013). The most significant factor in achieving long-term performance and ensuring its sustainability is the psychological competencies of the athletes (Cerit et al., 2013; Konter, 1998). Performance is one of the most extensively studied topics regarding athletes at both national and international levels (Çiftçi et al., 2021; Taylor & Wilson, 2005; Yarayan & İlhan, 2018). Therefore, it is essential to investigate the variables that will enhance athletic performance, especially among young female athletes.

Self-efficacy is an individual's self-assessment or judgment regarding their capacity to successfully perform a specific task (Bandura, 1997). Self-efficacy is an indicator of athletes' success and performance levels, facilitating the realization of desired thoughts and behaviors. Therefore, it is extremely important for athletes in the domains where they demonstrate performance and in relation to their competitors (Mutlu & Yıldızhan, 2023; Türedi, 2015). According to the results of studies in the literature, individuals with a high perception of self-efficacy tend to exert great effort to achieve a task, are less likely to give up when facing adverse situations and demonstrate persistence and patience in their endeavors (Aşkar & Umay, 2001; Hevedanlı & Ekici, 2009). A high level of self-efficacy in athletes is associated with a positive influence on athletic performance. It encourages the formation of confidence in the athlete and the projection and dissemination of that confidence to others, significantly impacting the enhancement of athletes' performance levels (Holzberger et al., 2013; Valiante & Morris, 2013). The scenarios created by individuals with high self-efficacy perceptions will guide them positively and affect their performance favorably. In other words, as individuals' perceptions of self-efficacy increase, so does the effort they put forth to achieve their goals (Bandura, 1994; Kartal, 2021).

The literature includes studies examining the relationship between self-efficacy and performance (Bouffard-Bouchard, 1990; Cherian, 2013; Schunk, 1995; Vancouver, 2002; Wright, 2016). This study anticipates that self-efficacy will positively influence the athletic performance of young female athletes.

The perception of self-efficacy plays an important role in defining emotions, thoughts, motivations, and behaviors in individuals (Bandura, 1994). Bandura describes low self-efficacy as associated with depression, anxiety, and helplessness (Bandura, 1977; Toklu, 2010). In the face of these undesirable outcomes, individuals may experience increased anxiety levels and a higher risk of making mistakes (Özkan, 2019). In the study by Mutlu & Yıldızhan, (2023) it was noted that as

anxiety increases, self-efficacy decreases. High self-efficacy in athletes helps to eliminate anxiety and enhance effort, thereby indirectly affecting the athlete's performance (Koçak, 2019). The perception of self-efficacy increases an individual's motivation, fosters happiness, and facilitates personal achievements (Toklu, 2010). Individuals with high self-efficacy can also experience positive emotions in challenging tasks and activities (Bandura, 1994). Koçak & Çolak (2024), stated that as women's self-efficacy increases, their ability to cope with stress also shows a positive trend. A review of the literature reveals that studies related to self-efficacy have observed that high self-efficacy generates positive emotions, while low self-efficacy leads to negative emotional states (Koçak, 2019; Koçak & Çolak, 2024; Mutlu & Yıldızhan, 2023). Therefore, it is anticipated that young female athletes with high self-efficacy will have positive emotional states, while those with low self-efficacy will experience negative emotional states.

One of the important concepts that plays a significant role in athletes achieving high performance is optimal performance emotional state (Yanar et al., 2017). Athletes with a high optimal performance emotional state experience an increase in positive emotions compared to those with a low optimal performance emotional state, which demonstrates the importance of optimal performance emotional state in sports (Rogatko, 2009). In their study, Yanar et al., (2017) addressed the optimal performance emotional state as having an indirect effect on athletes' performance in terms of being willing and engaged during competitions, noting that young athletes' experiences of different emotional states during training or competition positively influenced their performance and success. Swann et al., (2012) indicated that factors such as sustainable focus, physical preparation, teamwork, positive mental attitude, and positive outcomes experienced before and during competition positively impact optimal performance emotional state, while factors such as physical problems, errors, inability to maintain focus, and negative mental attitudes have a negative effect. As studies have increased understanding of the impact of emotional states in the sports environment on athletic performance, there is a wealth of research related to the concept of optimal performance emotional state (Fournier et al., 2007; Jackson & Marsh, 1996; Kawabata, et al., 2008; Keller & Bless, 2008; Moneta, 2004a; Moneta, 2004; Yanar et al., 2017). Based on the literature, it is anticipated that the positive and negative emotional states of young female athletes will mediate the relationship between self-efficacy and athletic performance.

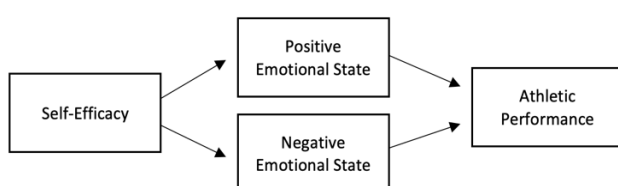


Figure 1. Research Model

Method

Study Group and Process

The sample group of the study consists of young female athletes from various university teams in Turkey. After obtaining ethical approval for the study, data were collected online. Data from a total of 25 female athletes were excluded from the analysis: 12 athletes were identified as providing false information, and 13 athletes reported having physical or mental issues. The total sample for the study comprises 339 female athletes. All analyses were conducted on the 339 young female athletes. The average age of the participants was 21.04 (Sd.=2.25). The average years of experience in their current disciplines was calculated to be 6.77 (Sd.=2.65). The calculation of sample size was based on the reference data reported in Lochbaum et al., (2023) systematic review. In the calculations, the number of independent variables ($u=3$), an anticipated effect size ($f^2=0.096$), a statistical power level of 95%, and an alpha of 0.05 were taken into consideration, resulting in a required sample size of 194 participants.

Data Collection Tools

The data for the study were collected using the "Personal Information Form," the "Athlete Self-Efficacy Scale," the "Sport Emotion Scale," and the "Individual Performance Assessment."

Athlete Self-Efficacy Scale: The scale developed by Koçak, (2020) was used to measure athletes' self-efficacy. This scale, designed to assess athletes' personal competencies, consists of a total of 16 questions (e.g., "I can cope with difficulties that put pressure on me") and four sub-dimensions. A 5-point Likert scale ranging from 1 (Disagree) to 5 (Completely Agree) was used. The Cronbach's alpha coefficient calculated for the internal consistency of the scale was $\alpha = .91$.

Sport Emotion Scale: The original Sport Emotion Scale was developed by Jones et al., (2005) and was adapted into Turkish by Urfa & Aşçı, (2019). This scale, designed to assess athletes' emotional states, consists of a total of 22 questions and five sub-dimensions. It includes three negative emotions (anxiety, discomfort, anger) and two positive emotions (enthusiasm, happiness). The Cronbach's alpha coefficients calculated for the internal consistency of the scale were $\alpha = .94$ for negative emotions and $\alpha = .92$ for positive emotions.

Individual Performance Assessment: The assessment of perceived performance by athletes using a single question rather than multiple questions is considered more reliable by some researchers (Josefsson et al., 2019). Participants in the study were asked to respond to the question, "How would you evaluate your training in the last week?" using a 10-point Likert scale (1 = very poor, 10 = very good).

Data Analysis

In the study, the skewness and kurtosis values of the data were calculated to check whether the data met the assumption of univariate normality. A reference range of ± 2.00 was used for skewness and kurtosis values across all data (George & Mallery, 2019). Factor scores and their z-values were used to determine the significance values of the variables in the research. The bootstrap technique was employed to verify whether the relationships between variables were statistically significant (Preacher & Selig, 2012). In this study, 5,000 resampling options were chosen and calculated at a 95% confidence interval (MacKinnon et al., 2004). Statistical analyses of the data obtained for the study were performed using SPSS and R software packages. Additionally, in the multiple regression analysis conducted using the R program, the "lavaan," "semTools," and "pwr" packages were utilized.

Ethical Approval

This study was approved by the Ethics Committee of Batman University on 09.07.2024 with the decision number 167570.

Results

When examining Table 1, there are positive and significant relationships between self-efficacy and positive emotion ($r = .16$, $p < .01$) and performance ($r = .14$, $p < .01$). It was observed that positive emotions have a negative and significant relationship with negative emotions ($r = -.50$, $p < .01$) and a positive and significant relationship with performance ($r = .37$, $p < .01$). Negative emotions were found to have a negative and significant relationship with performance ($r = -.43$, $p < .01$), while no significant relationship was detected with self-efficacy ($r = -.04$, $p > .01$). Furthermore, when examining the kurtosis and skewness values of the data, it was determined that all variables were within normal ranges.

Findings

The descriptive statistics (skewness, kurtosis, mean, and standard deviation) and Pearson correlation coefficients among the study variables (self-efficacy, positive emotional state, negative emotional state, and individual performance assessment) presents in Table 1.

Table 1. Descriptive statistics and correlation values

Variables	Skewness	Kurtosis	Mean	SD	1	2	3	4
(1) Self-Efficacy	-1.01	0.54	3.51	0.62	1			
(2) Positive Emotional State	-0.37	-0.41	2.53	0.92	0.16**	1		
(3) Negative Emotional State	0.69	-0.35	1.34	0.86	-0.04	-0.50**	1	
(4) Individual Performance Assessment	-0.54	0.13	6.22	1.97	0.14**	0.37**	-0.43**	1

In the conducted study, self-efficacy is modeled as the input variable in the path analysis, while performance is modeled as the output variable. Positive and negative emotions are considered as the mediating variables in this relationship (Figure 1).

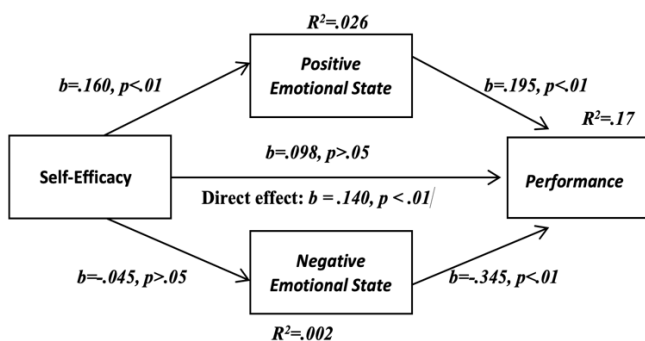


Figure 1. The Mediating Role of Negative and Positive Emotions in the Relationship Between Self-Efficacy and Performance

In the study, it was found that self-efficacy has a direct positive and significant effect on performance ($b = .140$, $p < .01$). As a result of the path model created, it was determined that self-efficacy has a positive and significant effect on positive emotions ($b = .160$, $p < .01$), while it has no effect on negative emotions ($b = -.045$, $p > .05$). The effect of positive emotions on performance is positive and significant ($b = .195$, $p < .01$), while negative emotions have a negative and significant effect on performance ($b = -.345$, $p < .01$). The indirect effect of self-efficacy on performance through negative and positive emotions was assessed using the Bootstrap technique with 5,000 resampling options. As a result of the bootstrap analyses, it was found that self-efficacy has an indirect effect on performance through positive emotions ($b = .031$, $p < .05$). However, no indirect effect was found through negative emotions ($b = .016$, $p > .05$).

Table 2. Findings Related to the Path Model

			% 95 CI			Sd	z-value	p (> z)
			B	LL	UL			
Direct Effect								
Self-Efficacy	→	Positive Emotion	0.16**	0.089	0.385	0.075	3.14	0.00
Self-Efficacy	→	Negative Emotion	-0.04	-0.210	0.085	0.075	-0.83	0.40
Self-Efficacy	→	Performance	0.09	0.616	0.300	0.161	1.86	0.06
Positive Emotion	→	Performance	0.19**	0.142	0.667	0.134	3.01	0.00
Negative Emotion	→	Performance	-0.34**	-1.016	-0.515	0.128	-5.99	0.00
Indirect Effect								
Self-Efficacy	→	Positive Emotion → Performance	0.31*	0.008	0.184	0.045	2.14	0.03
Self-Efficacy	→	Negative Emotion → Performance	0.01	-0.066	0.161	0.058	0.82	0.40

** $p < 0.01$, * $p < 0.05$

Discussion

The aim of this study is to investigate the role of emotions in the relationship between self-efficacy (belief in oneself, the conviction of being able to achieve success) and performance among young female athletes. A cross-sectional study has been designed to test the formulated research hypotheses, focusing on the mediating role of both positive and negative emotions.

In our study, the findings indicate a reciprocal relationship between the self-efficacy of young female athletes and their positive emotional states. These results are consistent with previous research (Burić & Macuka, 2018; Zhen et al., 2017). Self-efficacy has been identified as a significant factor influencing emotion regulation in various studies (Alessandri et al., 2014). Young female athletes with high levels of self-efficacy tend to provide positive feedback to their surroundings. When evaluated within the framework of Self-Determination Theory (Deci & Ryan, 2008), this finding suggests that the belief in their ability to complete a task or achieve success with the necessary performance can enhance their intrinsic motivation. Increased intrinsic motivation may trigger the formation of positive emotional experiences (such as happiness or excitement) among young female athletes. According to Self-Determination Theory, competence is a crucial factor in enhancing motivation (Ryan & Deci, 2000). Karakuş & Başer, (2022) noted that self-efficacy might vary by gender due to obstacles in different social environments. In particular, young female athletes may have a greater need to demonstrate this competence and prove themselves compared to their male counterparts. Indeed, a study conducted by Demirtaş, (2018) found a significant difference in the self-efficacy levels of males compared to females.

Our research has found a significant and positive relationship between positive emotions and performance. This finding is consistent with numerous theoretical studies and research in the literature (Kavanagh & Hausfeld, 1986; Rathschlag & Memmert, 2015). Various theoretical approaches exist regarding how positive emotions can influence performance. According to Carver & Scheier, (1998)'s self-regulation theory, individuals utilize their positive emotions as a motiva-

tional force to achieve their goals. Thus, positive emotions can enable athletes to be willing and determined in achieving their performance. On the other hand, Isen ve Reeve, (2005) stated that positive emotions assist individuals in attaining higher success during the problem-solving process. In this context, young female athletes experiencing positive emotions may create favorable effects on their performance based on their problem-solving and creative thinking abilities. Lazarus, (2000) posited that when the necessary skills are present in an individual, happiness can enhance performance. When evaluated from the perspective of young female athletes, it is observed that women have a higher capacity for emotion regulation compared to men (Gross & John, 2003; McNulty & Fincham, 2012; Tamres et al., 2002). This situation may stem from women's more active engagement in seeking emotional support and regulating their emotions (Tamres et al., 2002). Of course, the outcomes of this study may vary based on regional and cultural contexts.

In the study, no significant relationship was found between self-efficacy and negative emotions among young female athletes. This result differs from some studies in the literature (Burić & Macuka, 2018; Zhen et al., 2017). While it has been noted that women experience emotional disorders more frequently than men (Kuehner, 2017), it can be argued that this may differ specifically for young female athletes. This finding may suggest that the emotional responses of young female athletes could be more balanced. In their studies on emotion regulation processes that shape individuals' emotions, Gross & John, (2003), revealed that different appraisal styles are effective in suppressing emotions. Women's more active use of emotional support and reappraisal strategies (Gross & John, 2003; Tamres et al., 2002) may have enabled young women with high self-efficacy to better manage negative emotions such as stress or anxiety, thereby distancing themselves from negative emotions. In this context, it is believed that the emotion regulation strategies used by women can enhance the positive effects of self-efficacy on positive emotions while facilitating avoidance of negative emotions.

In the study, when examining the relationship between negative emotions and performance, it was concluded that negative emotions adversely affect performance. This finding supports several meta-analyses in the literature (Craft et al., 2003; Woodman & Hardy, 2003). Particularly in instances of experiencing negative emotions such as stress and anxiety, individuals may struggle to focus on their tasks, leading to a decline in performance. According to Eysenck et al., (2007) in their theory of attentional control, when anxiety levels rise, cognitive resources may become depleted, causing individuals to struggle in directing their attention toward performance. This situation can result in a decrease in performance. Additionally, negative emotions can lead to a lack of motivation in individuals, which may also contribute to a decline in performance (Carver & Scheier, 1998). When evaluated from the perspective of young female athletes, it should be considered that women may experience more intense emotional responses than men and may be more prone to emotional disorders (Kuehner, 2017). They may carry a heavier emotional burden due to hormonal changes and social environmental pressures. This situation could result in the effects of negative emotions on performance being more pronounced than those of positive emotions among young female athletes.

Conclusions

In this study, while the effect of self-efficacy on performance through positive emotions was found to be significant, it was concluded that self-efficacy did not influence performance through negative emotions. High levels of self-efficacy may enable individuals to develop positive emotions and utilize these feelings to enhance their performance. Individuals with high self-efficacy can manage stress and anxiety more effectively due to their confidence, thereby experiencing the performance-enhancing effects of positive emotions more distinctly. However, the study found that self-efficacy did not impact performance through negative emotions. This finding suggests that the effect of negative emotions on performance may not be direct and that self-efficacy's ability to manage these emotions may be associated with different variables. It can be asserted that self-efficacy does not predict negative emotions as strongly as it does positive emotions, or at least that this prediction is not sufficiently evident in the current sample group.

Future research could conduct more detailed investigations into how self-efficacy manages negative emotions. The effects of emotional regulation strategies associated with self-efficacy (Gross & John, 2003), on both positive and negative emotions could be examined. Such studies could enhance our understanding of the role of self-efficacy in emotional management and clarify its effects on performance in greater detail. Additionally, comparative studies examining differences between males and females could more clearly elucidate the effects of gender on self-efficacy and emotional regulation.

Conflict of Interest

The authors of the article declare that there are no personal or financial conflicts of interest related to the study.

Author Contributions

Research Idea: SS; **Research Design:** SS, BŞ; **Data Analysis:** YY; **Manuscript Writing:** BŞ, SS, YEY, AE; **Critical Review:** SB

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Socialization Levels and Job Satisfaction of Secondary School Physical Education Teachers

Ortaöğretim Beden Eğitimi Öğretmenlerinin Sosyalleşme Düzeyleri ve İş Doyumu

Research Article / Araştırma Makalesi

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Received / Geliş Tarihi : 25.01.2025
Accepted / Kabul Tarihi : 19.03.2025
Published / Yayın Tarihi : 25.03.2025

Ethical Statement / Etik Bilgilendirme
This study was approved by the Social Sciences Research Ethics Committee of Aydın Adnan Menderes University, with the decision dated December 5, 2022, and numbered 17.

DOI: 10.53434/gbesbd.1626825

Abstract

The middle school period, during which students begin to explore their identities, develop social skills, and strengthen their academic foundations, is a critical time for teachers in their guiding role. In this context, our study focuses on examining the relationship between the socialization levels and job satisfaction of 205 middle school physical education and sports teachers in Aydın within the framework of demographic variables. The results of the research were examined using SPSS, applying parametric tests, MANOVA, and linear regression analysis. For the study, a personal information form, the job satisfaction scale validated by Başol and Çömlekçi (2020), and the Organizational Socialization Scale created by Erdoğan and Dönmez (2019) were utilized. The findings suggest that educators possess a high degree of socialization, which positively affects their job satisfaction. Notably, age and professional experience plays a crucial role in shaping educators' social interactions and job satisfaction. In relation to gender, female teachers were more active in social interactions, while teachers with a bachelor's degree perceived their social relationships more positively. These findings highlight the necessity the need for educational institutions to develop strategies aimed at strengthening teachers' social interactions

Keywords: Physical education teacher, Job satisfaction, Socialization

Öz

Öğrencilerin kimliklerini keşfetmeye başladığı, sosyal becerilerini geliştirdiği ve akademik temellerini güçlendirdiği ortaokul dönemi, öğretmenlerin rehberlik rolü açısından kritik bir zamandır. Bu bağlamda araştırmamız, Aydın'da bulunan 205 beden eğitimi ve spor branşı ortaokul öğretmenin sosyalleşme düzeyleri ile iş tatmini arasındaki ilişkiyi demografik değişkenler çerçevesinde incelemeye odaklanmıştır. Araştırma sonuçları SPSS, parametrik testler, MANOVA ve doğrusal regresyon analizi kullanılarak incelenmiştir. Çalışmada kişisel bilgi formu, Başol ve Çömlekçi (2020) tarafından geçerliliği kanıtlanmış iş tatmini ölçeği ve Erdoğan ve Dönmez (2019) tarafından oluşturulan Örgütsel Sosyalleşme Ölçeği kullanılmıştır. Bulgular, eğitimcilerin yüksek düzeyde sosyalleşmeye sahip olduğunu ve bunun iş tatminlerini olumlu yönde etkilediğini göstermektedir. Özellikle yaş ve mesleki deneyim, eğitimcilerin sosyal etkileşimlerini ve iş tatminlerini şekillendirmede önemli bir rol oynamaktadır. Cinsiyete göre, kadın öğretmenler sosyal etkileşimlerde daha aktifken, lisans derecesine sahip öğretmenler sosyal ilişkilerini daha olumlu algılamaktadır. Bu bulgular, eğitim kurumlarının öğretmenlerin sosyal etkileşimlerini güçlendirmeye yönelik stratejiler geliştirmesinin gerekliliğini ortaya koymaktadır.

Anahtar Kelimeler: Beden eğitimi öğretmeni, İş tatmini, Sosyalleşme

Introduction

Middle school teachers play a vital role in a significant period of students' lives. During this time, students begin to explore their identities, develop social skills, and solidify their academic foundations. This phase, referred to by researchers in various ways, is undeniably important in a child's life. Eccles and Midgley (1989) term this phases the "Developmental Period". They assert that students are striving to gain insight into themselves and their surroundings throughout this phase, which is considered the onset of adolescence. They argue that middle school teachers contribute significantly to students' emotional and social development by providing guidance through this complex period.

Jenkins, Fuchs, Fuchs & McGlinchey, (2015) refer to this phase as the "Academic Foundation". They view it as a critical stage where students develop their academic skills, emphasizing that the knowledge and abilities acquired during this time directly impact success at university or the high school degree. Research indicates that a strong middle school education has long-term effects on students' academic achievements (Jenkins et al., 2015; Hargreaves, 2000). Wentzel (2010) describes this period as the "Development of Social Skills" highlighting that students enhance their social skills through group work and projects, learning to collaborate, which is vital for both academic success and future professional life.

Additionally, considering that students' motivation and sense of belonging develop during this period, numerous studies suggest that effective middle school teachers can increase students' interest in lessons, promote school success, and enhance students' attachment to school in parallel with their relationships with teachers (Smith, Andrews, & DeMink-Carthew, 2024). It has been shown that middle school educators play a critical role in understanding and supporting students' individual needs, adapting teaching methods to different learning styles and requirements, leading to better learning outcomes. For these reasons, middle school teachers not only provide academic knowledge but also play a critical role in the interpersonal and emotional progress of their students. Thus, the job satisfaction and comfort of middle school teachers who significantly influence the quality of the learning atmosphere and students' academic success are essential. Their levels of socialization and job satisfaction are considered two key concepts that directly influence and regulate teachers' ability to cope with challenges in their professional lives, their professional development, and their interactions with students.

The level of socialization among middle school teachers determines the nature of their engagements with students, parents and colleagues. Social interaction enhances teachers' commitment and motivation in the workplace. Teachers with high levels of socialization can collaborate and share knowledge and experiences, contributing to the development of their pedagogical practices (Hargreaves, 1994).

Additionally, social support helps teachers cope with stress and build resilience against emotional exhaustion (Bakar, LeTendre & Wiseman, 2015).

Job satisfaction is defined as the presence of positive and pleasant attitudes and feelings in workers in relation to their work environment (Zhu, 2013; Quesada Puga et al., 2024). Job satisfaction is also a factor that increases teachers' commitment to and motivation in their profession. High job satisfaction allows teachers to cultivate a more positive outlook on their work, perform better, and guide students more effectively (Skaalvik & Skaalvik, 2014). Furthermore, teachers' job satisfaction affects the overall atmosphere of the educational environment, thereby enhancing students' learning motivation. In particular, the sense of satisfaction reinforces teachers' willingness to improve their professional competencies and implement innovative teaching methods (Shen, 2012; Niu et al., 2023). The levels of integration and work satisfaction among high school teachers are vital not only for the individuals involved but also for the overall effectiveness of the education system. These two factors directly impact teachers' professional development, their engagements with students, and the general educational quality of the school, helping to establish a positive educational atmosphere.

This study seeks to investigate the connection between middle school physical education teachers' socialization levels and their job satisfaction, considering demographic factors such as education level, gender, age, and years of service. Specifically, the study seeks to understand how physical education teachers' social interactions and professional support systems affect their job satisfaction. By revealing the connection between the degree of socialization and physical education teachers' job satisfaction, the research seeks to assist in the advancement of strategies that enhance teachers' professional development and psychological well-being within educational institutions. Additionally, by identifying the role of demographic variables in this relationship, the study aims to help create more effective support mechanisms for different groups.

Method

Research Model

This research was conducted using the correlational survey model, one of the quantitative research methods. The correlational survey model is used to determine the existence and degree of change between two or more variables. Accordingly, relational analysis can be performed in two ways: correlation-type relationships and relationships obtained through comparison. This approach facilitates the identification of attitudes and tendencies (Creswell, 2017).

Study Group

The study group for this research consists of middle school physical education teachers in the Aydın district. Data were provided to participants via Google Drive, and participation was based on voluntary consent. A total of 211 participants were reached, but 205 were included in the evaluation. The sample size was determined based on studies available in the literature (Baş & Coşkun, 2020; Karadağ & Karataş, 2018), and the obtained data size was deemed sufficient.

Table 1. Descriptive variables

Variables		f	%
Gender	Men	108	52,7
	Women	97	47,3
Age (years old)	22-27	11	5,4
	28-33	24	11,7
	34-39	65	31,7
	40-45	45	22,0
	> 46	60	29,3
Professional experience (years)	< 4	17	8,3
	5-9	17	8,3
	10-14	57	27,8
	15-19	46	22,4
	> 20	68	33,2
Educational status	Bachelor's Degree	179	87,3
	Graduate and Postgraduate	26	12,7
		205	100

In Table 1, the highest percentages for categorical variables are as follows: for gender, female participants constitute 52.7%; for age, those aged 34-39 make up 31.7%; for professional experience, individuals with 20 years or more account for 33.2%; and for educational background, bachelor's degree holders represent 87.3%.

Data Collection

The research is structured into three parts; the first one contains a personal information questionnaire, the second one features the job satisfaction scale created by Brayfield & Rothe (1951), which was later condensed by Judge, Erez & Bono (1998) and validated in Turkish by Başol & Çömlekçi (2020), while the third section includes the Organizational Socialization Scale created by Erdoğan & Dönmez (2019).

Personal Information Form: The form prepared by the researchers, consists of questions regarding age, gender, professional experience, and educational background.

Job Satisfaction Scale: The scale, created by Brayfield & Rothe (1951) and later condensed by Judge et al. (1998), was validated in Turkish by Başol & Çömlekçi (2020). This scale comprises 5 items and is unidimensional, demonstrating a

Cronbach's Alpha value of 0.929, which indicates high reliability. A 5-point Likert scale was used ranged from 1 (strongly disagree) to 5 (strongly agree). In our study, the Cronbach's Alpha value was determined to be 0.859. Therefore, it is evident that the scale used for middle school physical education teachers has high reliability.

Organizational Socialization Scale: The scale, created by Erdoğan & Dönmez (2019), comprises 24 items categorized into five dimensions: professional competence, organizational policy, organizational language and history, interpersonal relationships, and goals and values. A 5-point Likert scale was used (1- strongly disagree to 5- strongly agree). The Cronbach's Alpha coefficients for the scale were found to vary from 0.78 to 0.91, indicating acceptable to high reliability. In our study, the Cronbach's Alpha values for the sub-dimensions were found to range between 0.815 and 0.934. Thus, it is evident that the scale used for middle school physical education teachers also demonstrates high reliability.

Table 2. Reliability analysis

Scale Dimensions	Cronbach alpha
Interpersonal Relationships	,868
Organizational Policy	,815
Professional Competence	,867
Alignment with Goals and Values	,842
Organizational Language and History	,932
Organizational Socialization	,934
Job Satisfaction	,859

The reliability analysis obtained from the scales indicates that both the main scales and their sub-dimensions have high reliability coefficients (see Table 2).

Data Analysis

The results of this research were examined using SPSS version 25.0 software. To evaluate the normality assumption, skewness and kurtosis coefficients were assessed, showing values within the range of +2 to -2, which permitted the application of parametric tests in the analysis (Büyüköztürk et al., 2008). The statistical analyses included MANOVA, linear regression, and computations of percentages, frequencies, and reliability coefficients.

Ethical Statement

This study was approved by the Social Sciences Research Ethics Committee of Aydın Adnan Menderes University, with the decision dated December 5, 2022, and numbered 17.

Findings

In this section of the research, the results of the statistical analysis on teachers' job satisfaction and socialization levels are presented in tables, followed by explanations.

Table 3. Score distributions for the organizational socialization and job satisfaction scales

Scale Dimensions	n	\bar{x}	Sd	Skewness	Kurtosis
Interpersonal Relationships	205	4,03	,60	-,202	-,469
Organizational Policy	205	3,84	,65	-,141	-,295
Professional Competence	205	4,17	,56	-,165	-,475
Alignment with Goals and Values	205	4,13	,61	-,499	,228
Organizational Language and History	205	4,04	,86	-1,145	1,145
Organizational Socialization	205	4,05	,50	-,317	,043
Job Satisfaction	205	4,02	,52	-,257	,415

According to Table 3, participants' scores on the Organizational Socialization Scale and its sub-dimensions are high. Among these dimensions, the highest average is observed in the professional competence dimension ($\bar{x} = 4.17$). Additionally, the scores on the Job Satisfaction Scale are also high ($\bar{x} = 4.02$).

Table 4. Pearson correlation analysis

	International Relationship	Organizational Policy	Professional Competence	Alignment with Goals and Values	Organizational Language and History	Organizational Socialization	Job Satisfaction
Organizational Policy	,512** ,000	1 -					
Professional Competence	,642** ,000	,702** ,000	1 -				
Alignment with Goals and Values	,548** ,000	,444** ,000	,622** ,000	1 -			
Organizational Language and History	,432** ,000	,271** ,000	,342** ,000	,562** ,000	1 -		
Organizational Socialization	,822** ,000	,722** ,000	,831** ,000	,817** ,000	,695** ,000	1 -	
Job Satisfaction	,414** ,000	,638** ,000	,623** ,000	,471** ,000	,247** ,000	,596** ,000	1 -

$p < 0,01^{**}$, $p < 0,05^{*}$

According to the findings shown in Table 4, there is a positive, moderately significant relationship between the participants' job satisfaction and interpersonal relations ($r=.414$); a moderately significant relationship with organizational policy ($r=.638$); a moderately significant relationship with professional competence ($r=.623$); a moderately significant relationship with compliance with goals and values ($r=.471$); a low-level significant relationship with organizational language and history ($r=.247$) and a moderately significant and positive relationship with organizational socialization ($r=.596$).

Table 5. Linear regression analysis carried out to assess the impact of organizational socialization on job satisfaction

Independent Variables	Dependent Variables	B	t	p	F	R2	Durbin Watson
Constant	Interpersonal Relationships	1,343	6,060	,000			
	Organizational Policy	,352	4,710	,000			
	Professional Competence	,298	2,716	,007			
	Alignment with Goals and Values	,170	1,947	,053			
	Organizational Language and History	,011	,178	,859			
	Organizational Socialization	-,164	-,668	,505			
Job Satisfaction					36,817	,467	1,905

Table 5 displays the outcomes of a linear regression analysis aimed at explaining the impact of Organizational Socialization on Job Satisfaction. In the established model, organizational socialization explains 46.7% of job satisfaction ($R^2=0.467$). A 1-unit increase in the organization policy variable causes a .352 increase in job satisfaction ($\beta=.352$); a 1-unit increase in the professional competence variable causes a .298 increase in job satisfaction ($\beta=.298$); a 1-unit increase in the purpose and value variable causes a .170 increase in job satisfaction ($\beta=.170$). It can be observed that organizational language and history, as well as Organizational Socialization do not exert a statistically significant influence on job satisfaction ($p>0.05$).

Table 6. MANOVA analysis of job satisfaction and organizational socialization according to age variable

<i>Dimensions</i>	<i>Age</i>	<i>N</i>	<i>\bar{X}</i>	<i>Sd</i>	<i>F</i>	<i>p</i>	<i>Bonferroni</i>
International Relationship	¹ 22-27	11	4,22	,44	2,566	,039*	4>3
	² 28-33	24	3,93	,62			
	³ 34-39	65	3,87	,61			
	⁴ 40-45	45	4,13	,64			
	⁵ > 46	60	4,15	,56			
Organizational Policy	¹ 22-27	11	3,31	,85	3,784	,005*	5>1
	² 28-33	24	3,59	,61			
	³ 34-39	65	3,87	,63			
	⁴ 40-45	45	3,85	,66			
	⁵ > 46	60	4,00	,55			
Professional Competence	¹ 22-27	11	4,07	,70	1,054	,381	-
	² 28-33	24	4,08	,56			
	³ 34-39	65	4,11	,58			
	⁴ 40-45	45	4,30	,61			
	⁵ > 46	60	4,20	,47			
Alignments with Goals and Values	¹ 22-27	11	3,87	,57	2,127	,079	-
	² 28-33	24	4,13	,52			
	³ 34-39	65	4,00	,63			
	⁴ 40-45	45	4,22	,64			
	⁵ > 46	60	4,25	,57			
Organizational Language and History	¹ 22-27	11	4,15	,91	2,070	,086	-
	² 28-33	24	4,08	,67			
	³ 34-39	65	3,80	,87			
	⁴ 40-45	45	4,10	,86			
	⁵ > 46	60	4,22	,88			
Organizational Socialization	¹ 22-27	11	3,95	,52	2,246	,065	-
	² 28-33	24	3,97	,45			
	³ 34-39	65	3,93	,52			
	⁴ 40-45	45	4,13	,52			
	⁵ > 46	60	4,17	,46			
Job Satisfaction	¹ 22-27	11	3,67	,54	5,308	,000*	5>1 4,5>2
	² 28-33	24	3,70	,64			
	³ 34-39	65	4,00	,47			
	⁴ 40-45	45	4,14	,47			
	⁵ > 46	60	4,15	,49			

p<0,05*

Table 6 shows a statistically significant variation in the overall scores for Interpersonal Relations, Organizational Policy, and job satisfaction, according to the findings from the MANOVA analysis conducted between the participants' organizational socialization, job satisfaction, and the age variable ($p<0.05$). These results show that respondent in the 40-45 age range scored higher in the Interpersonal Relations dimension compared to those in the 34-39 age range. In the Organizational Policy dimension, participants aged 46 and above scored higher than those in the 22-27 age range. Furthermore, in the overall job satisfaction score, participants aged 46 and above had higher scores than those in the 22-27 age group, while those aged 40-45 and 46 and above scored higher than participants aged 28-33.

Table 7. MANOVA analysis of job satisfaction and organizational socialization based on gender

<i>Dimensions</i>	<i>Gender</i>	<i>Sd</i>	<i>\bar{X}</i>	<i>N</i>	<i>F</i>	<i>p</i>
International Relationship	Women	4,04	,54	108	,015	,902
	Men	4,03	,67	97		
Organizational Policy	Women	3,81	,66	108	,530	,467
	Men	3,87	,63	97		
Professional Competence	Women	4,20	,56	108	,641	,424
	Men	4,14	,56	97		
Alignments with Goals and Values	Women	4,14	,57	108	,072	,789
	Men	4,11	,65	97		
Organizational Language and History	Women	4,21	,72	108	8,927	,003*
	Men	3,85	,96	97		
Organizational Socialization	Women	4,08	,44	108	,943	,333
	Men	4,01	,56	97		
Job Satisfaction	Women	3,98	,52	108	1,267	,262
	Men	4,07	,52	97		

p<0,05*

Table 7 shows that, based on the MANOVA analysis conducted between organizational socialization, job satisfaction, and the gender variable, a statistically meaningful difference exists, favoring female participants, specifically in the dimensions of organizational language and history ($p<0.05$).

Table 8. MANOVA analysis of job satisfaction and organizational socialization based on years of professional experience

<i>Dimensions</i>	<i>Year of profession</i>	\bar{X}	<i>SS</i>	<i>N</i>	<i>F</i>	<i>p</i>	<i>Bonferroni</i>
International Relationship	¹ < 4	4,17	,49	17	2,418	,050*	5>3
	² 5-9	3,95	,66	17			
	³ 10-14	3,84	,56	57			
	⁴ 15-19	4,11	,71	46			
	⁵ > 20	4,13	,55	68			
Organizational Policy	¹ < 4	3,30	,75	17	3,961	,004*	3,4,5>1
	² 5-9	3,80	,61	17			
	³ 10-14	3,81	,56	57			
	⁴ 15-19	3,89	,76	46			
	⁵ > 20	3,98	,56	68			
Professional Competence	¹ < 4	4,02	,66	17	1,071	,372	-
	² 5-9	4,12	,61	17			
	³ 10-14	4,10	,50	57			
	⁴ 15-19	4,28	,63	46			
	⁵ > 20	4,20	,52	68			
Alignments with Goals and Values	¹ < 4	3,89	,50	17	2,176	,073	-
	² 5-9	4,27	,62	17			
	³ 10-14	4,00	,57	57			
	⁴ 15-19	4,14	,70	46			
	⁵ > 20	4,25	,57	68			
Organizational Language and History	¹ < 4	4,32	,80	17	1,612	,173	-
	² 5-9	4,04	,77	17			
	³ 10-14	3,86	,81	57			
	⁴ 15-19	3,95	,96	46			
	⁵ > 20	4,18	,85	68			
Organizational Socialization	¹ < 4	3,96	,48	17	1,783	,134	-
	² 5-9	4,04	,48	17			
	³ 10-14	3,93	,46	57			
	⁴ 15-19	4,09	,58	46			
	⁵ > 20	4,15	,47	68			
Job Satisfaction	¹ < 4	3,60	,57	17	5,374	,000*	4,5>1
	² 5-9	3,82	,58	17			
	³ 10-14	3,98	,43	57			
	⁴ 15-19	4,09	,59	46			
	⁵ > 20	4,17	,45	68			

$p<0,05^*$

Table 9. MANOVA analysis of organizational socialization and job satisfaction according to education variable

<i>Dimensions</i>	<i>Education</i>	<i>Sd</i>	\bar{X}	<i>N</i>	<i>F</i>	<i>p</i>
International Relationship	Bachelor's degree	4,07	,60	179	4,828	,029*
	Postgraduate	3,79	,61	26		
Organizational Policy	Bachelor's degree	3,85	,65	179	,391	,533
	Postgraduate	3,76	,63	26		
Professional Competence	Bachelor's degree	4,19	,57	179	1,703	,193
	Postgraduate	4,03	,53	26		
Alignments with Goals and Values	Bachelor's degree	4,16	,61	179	4,959	,027*
	Postgraduate	3,88	,56	26		
Organizational Language and History	Bachelor's degree	4,08	,84	179	2,847	,093
	Postgraduate	3,77	,94	26		
Organizational Socialization	Bachelor's degree	4,08	,49	179	4,609	,033*
	Postgraduate	3,85	,51	26		
Job Satisfaction	Bachelor's degree	4,04	,50	179	1,317	,252
	Postgraduate	3,91	,66	26		

$p<0,05^*$

Table 8 shows that a statistically significant discrepancy exists in the overall score for Interpersonal Relations, Organizational Policy, and Job Satisfaction because of the MANOVA analysis conducted between participants' organizational socialization, job satisfaction, and the professional experience variable ($p < 0.05$). According to these findings, participants with 20 years or additional work experience scored higher in the Interpersonal Relations dimension compared to those with 10-14 years of experience. In the Organizational Policy dimension, participants with 10-14 years, 15-19 years, and 20 years or more of professional experience scored higher than those with 4 years or less. Regarding the total job satisfaction score, participants with 15-19 years and 20 years or more of experience had higher scores than those with 10-14 years of experience.

Table 9 shows that the MANOVA analysis conducted between participants' organizational socialization, job satisfaction, and the educational status variable reveals a statistically important discrepancy in the dimensions of Interpersonal Relations, Conformity to Goals and Values, and Organizational Socialization ($p < 0.05$). According to these findings, participants with a bachelor's degree scored higher than those with a graduate-level qualification in the dimensions of Interpersonal Relations, Conformity to Goals and Values, and Organizational Socialization.

Discussion

This study was conducted with the participation of 205 middle school physical education teachers from the Aydın district. The research aimed to examine the effect of physical educators' social interactions and professional support systems on their job satisfaction. By exploring the impact of demographic factors on this relationship, the research seeks to support the development of more tailored support systems for various groups. Additionally, by revealing the connection between socialization levels and teachers' job satisfaction, the study aims to illuminate strategies for enhancing professional development and psychological well-being in educational institutions. The key highlight of this study is that teachers' job satisfaction in educational institutions emerges as a critical factor that directly influences not only their individual performance but also students' academic achievement and the overall quality of education. However, the relationship between teachers' social interactions, professional support systems, and job satisfaction has not been explored in sufficient depth. This study aims to fill this significant gap in the literature by examining the impact of physical education teachers' social connections and support mechanisms on their job satisfaction.

When examining the results on the Organizational Socialization Scale and its sub-dimensions, it is evident that physical education teachers possess high average scores, with the highest average found in the professional competence dimension ($\bar{x} = 4.17$). This finding indicates the existence of strong social

interactions among teachers and suggests that social support and collaboration positively influence their professional development. Particularly, the high average in the professional competence dimension reflects teachers' confidence in their professional abilities and the significance they place on their development. This result aligns with earlier studies that highlight the vital importance of organizational socialization in enhancing individuals' professional competencies and job satisfaction (Bakar et al., 2015; Johnson, 2016). Moreover, the high score on the Job Satisfaction Scale ($\bar{x} = 4.02$) indicates that teachers generally experience positive job satisfaction and that social interactions significantly impact their overall satisfaction. In conclusion, these findings underscore the importance for educational institutions to enhance social support mechanisms, highlighting the impact of social interactions and professional competence on physical education teachers' job satisfaction.

The positive, moderate correlations found between physical education teachers' job satisfaction and interpersonal relationships ($r = 0.414$), organizational policy ($r = 0.638$), professional competence ($r = 0.623$), and alignment with goals and values ($r = 0.471$) indicate that these factors significantly influence teachers' job satisfaction. Notably, the strong connection between organizational policy and job satisfaction ($r = 0.638$) supports the notion that effective management practices and open communication play a critical role in enhancing teachers' job satisfaction (Bil, 2018; Yücekaya & Polat, 2020). Additionally, the connection between professional competence and job satisfaction ($r = 0.623$) suggests that teachers' confidence in their competencies positively influences their job satisfaction, emphasizing the significance of programs that support their professional development (Altınkurt & Yılmaz, 2014; Hargreaves, 2000).

The moderate relationships between interpersonal relationships, alignment with goals and values, and job satisfaction ($r = 0.414$ and $r = 0.471$, respectively) reveal the impact of social support and organizational culture on physical education teachers' satisfaction (Coppe Sarazin, März, Dupriez & Raemdonck, 2022; Bahtilla & Hui, 2021). Conversely, the low significant relationship between organizational language and history and job satisfaction ($r = 0.247$) suggests that these elements may have a lower impact and might not directly influence teachers' satisfaction. Additionally, the moderately remarkable connection between job satisfaction and organizational socialization ($r = 0.596$) underscores the importance of teachers' social interactions in enhancing their job satisfaction. This finding suggests that nurturing strong social connections among teachers can create a positive atmosphere in educational settings and highlights the necessity for innovative strategies that promote social interactions and enhance professional competencies (Gardner Huang, Pierce, Niu & Lee, 2022; Adil Kausar, Ameer, Ghayas & Shujja, 2023). Linear regression analysis showed a notable influence of organizational socialization on job satisfaction. When evaluated with its sub-dimensions, an increase of one unit in

organizational policy, professional competence, and alignment with goals and values variables leads to varying degrees of increase in job satisfaction. This suggests that effective organizational policies can significantly enhance physical education teachers' job satisfaction. Open and supportive organizational policies positively influence teachers' satisfaction and motivation, thereby impacting their overall job satisfaction. Conversely, the lack of a statistically significant effect of organizational language and history on job satisfaction ($p > 0.05$) suggests that these variables have limited influence on job satisfaction. This implies that organizational language and history may not be determining factors for teachers' job satisfaction. Therefore, it may be advisable for educational institutions to focus on more effective social interactions and professional development opportunities to enhance teachers' job satisfaction. Existing research supports our results (Brazicha et al., 2020; Yavuzkurt & Kiral, 2020; Adil et al., 2023).

The research findings provide significant insights into understanding the effects of age on organizational socialization and job satisfaction. A meaningful difference is noted between interpersonal relationships, organizational policy, and overall job satisfaction scores ($p < 0.05$). Based on these findings, participants aged 40-45 scored higher in the sub-dimensions of interpersonal relationships and organizational policy compared to those in the 34-39, 28-33, and 22-27 age groups. Similar results are evident in job satisfaction scores. This may be understood as an increase in age correlating with enhanced competency in understanding and adapting to organizational policies, thereby facilitating quicker adaptation to the organizational structure and a greater openness to policy changes, which in turn increases job satisfaction. In conclusion, these findings clearly illustrate the effects of age on organizational socialization and job satisfaction, indicating that educational institutions should develop different strategies tailored to various age groups. Specifically, increasing social support and professional development opportunities for younger teachers could be an important step in enhancing their job satisfaction. Many studies have noted similar results regarding the age variable, indicating that increased age is associated with positive outcomes (Yavuzkurt & Kiral, 2020; Rauvola Rudolph, Ebbert & Zacher, 2020; Livi, De Cristofaro, Theodorou, Rullo, Piccioli & Pozzi, 2020).

In the study, analyses examining the connection between organizational socialization and job satisfaction in relation to gender showed no significant differences. Nevertheless, a statistically notable disparity was observed in the sub-dimension of organizational language and history, favoring female participants. Organizational language and history are crucial elements that reflect the cultural context and communication style of an organization. The higher scores of women in this area may indicate that they are more active or effective in social interactions within the organization, as well as feeling a stronger commitment to the organizational culture and values. The positive perceptions of female participants regarding organizational

language and history may reflect the interplay between gender roles and organizational support mechanisms. This may also suggest that female physical education teachers have more opportunities to strengthen social ties, facilitate communication, and align with organizational values, or that they are more motivated to develop these aspects. Although some studies have shown higher scores among men, the literature generally indicates that women tend to score higher (Spagnoli, 2020; Cepale Alessandri, Borgogni, Perinelli, Avanzi, Livi & Coscarelli, 2021; Yang, Zhou, Peng & Li, 2023; Hafeez, Zahrah, Tahir & Aslam, 2023).

Examining how physical education teachers' professional experiences affect job satisfaction and organizational socialization, it is noted that average scores increase with experience in both criteria. Specifically, in the sub-dimension of interpersonal relationships, the scores reflect a high level at the beginning of the career, followed by a decline over the years. This may suggest that less experienced teachers perceive their social interactions more positively, while those with intermediate to advanced experience may experience a certain regression in their social relationships. In terms of organizational policy, it is observed that the average scores of novice teachers rise with increasing professional experience. This indicates that as teachers gain experience, their competencies in understanding organizational policies and adapting to them improve. Job satisfaction also reaches higher average scores with increasing experience, showing that accumulated experience positively affects job satisfaction over time. The findings highlight that professional experience significantly influences teachers' perceptions of interpersonal relationships, organizational policy, and job satisfaction (Adil et al., 2023; Richter, Lucksnat, Redding & Richter, 2022). Therefore, educational institutions should develop strategies to strengthen social interactions and organizational policies by considering teachers' professional experiences. Additionally, creating supportive programs aimed at enhancing social relationships for less experienced teachers is thought to have the potential to increase their job satisfaction.

In terms of teachers' educational levels, significant effects were observed on their perceptions of interpersonal relationships, alignment with organizational socialization, values, and goals. Nevertheless, no notable variations were observed concerning organizational policy, literature competence, and job satisfaction. It appears that the average scores of teachers with a bachelor's degree in the sub-dimensions of interpersonal communication, alignment with organizational socialization, values, and goals are greater than those of educators with a graduate degree, indicating a significant difference. This may suggest that teachers with a bachelor's degree perceive their social interactions and literature relationships more positively, thus possessing a greater capacity to establish strong interpersonal connections. Likewise, it can be asserted that they are more aligned with institutional goals and values, feeling closer to the organizational culture. Additionally, it can be concluded

that educators holding a bachelor's degree experience organizational social interactions more effectively to establish their institutional networks. The literature supports these findings, with studies by Toprakçı & Avcı (2021), Çobanoğlu & Öğretir (2015), and Aranibar Baez-Lopez, Limon-Romero, Ramírez-Barón, García Rivera, Ortega-Pérez Tejada & Hernández Bejarano, (2022) showing similar results.

Conclusion

This research investigates the connection between organizational integration and work satisfaction within middle school physical education teachers in Aydın, with an emphasis on demographic variables (gender, age, professional experience and education level). The findings reveal that teachers typically report high levels of both job satisfaction and organizational socialization with significant positive correlations noted between job satisfaction and several dimensions of organizational socialization, especially organizational politics and professional competence. The findings suggest a moderately strong positive correlation between work fulfillment and the components of interpersonal relationships, organizational politics, professional competence, and alignment with organizational goals and values. Regression analysis further indicates that a rise in organizational socialization directly results in an enhancement in job satisfaction.

Considering age as a criterion, notable variations were found in the scores concerning interpersonal relationships, organizational politics, and overall job satisfaction. Specifically, it was discovered that with rising age (particularly in the 46 and over age group compared to the 40-45 age group), the average scores in interpersonal relationships, organizational politics, and job satisfaction also increased. When examining the gender variable, no significant results were found regarding overall degrees of job satisfaction and organizational socialization. However, a statistically significant difference favoring female participants emerged in the dimension of organizational language and history. Regarding the relationship with professional experience, substantial differences were observed in scores associated with interpersonal relationships, organizational politics, and general work satisfaction. These results mean that increasing professional experience correlates positively with higher average scores in interpersonal relationships, job satisfaction, organizational politics. In terms of education level, except for the sub-dimension of organizational language and history, it was determined that participants with a bachelor's degree scored higher than those with a postgraduate degree across all other sub-dimensions of organizational socialization and job satisfaction.

Author's Note

This research was previously presented as an oral presentation at the 2024 ERPA International Congress on Education held in Turkey.

Financial Resources

No financial support was received from any institution or organization during the preparation and writing of this study.

Conflict of Interest

There is no conflict of interest between the authors regarding the publication of this article.

Author Contributions

Research Idea: SAE; **Research Design:** GA, SAE; **Analysis of Data:** GA; **Article Writing:** BA, SY, GA; **Critical Review:** SAE

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Predictive Models of Hamstring Performance in Adolescent Athletes

Adolesan Sporcularda Hamstring Performansının Tahmin Modelleri

Research Article / Araştırma Makalesi

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Received / Geliş Tarihi : 15.01.2025

Accepted / Kabul Tarihi : 20.03.2025

Published / Yayın Tarihi : 25.03.2025

Ethical Statement / Etik Bilgilendirme

This study was approved by the Ethical
Committee of Kütahya Dumlupınar
University with decision number
12.08.2024-388.

DOI: 10.53434/gbesbd.1620255

Abstract

This study investigated the relationships between hamstring strength, flexibility, core endurance, jumping performance, single-leg bridge endurance, and knee joint range of motion (ROM) across six sports disciplines, including football, swimming, volleyball, karate, wrestling, and athletics. A total of 249 athletes (144 men, 105 women) aged 10–18 years participated, with a mean BMI of 22,6 kg/m² and an average of 4.9 years of sports experience. Regression analyses revealed sport-specific predictors of performance and injury risk. Dominant hamstring strength and torque were strong predictors of explosive movements like squat jumps in football ($R^2=0.74$, $p<0.001$) and volleyball ($R^2=0.71$, $p<0.001$), while balanced hamstring strength was critical for core stability in swimming ($R^2=0.62$, $p<0.05$). Non-dominant hamstring strength influenced squat jump performance in wrestling ($R^2=0.66$, $p<0.01$), and hamstring torque was significantly associated with knee flexion ROM in athletics ($R^2=0.72$, $p<0.001$). Inter-limb asymmetry exceeding 10% correlated with increased injury risk, highlighting the importance of symmetry. The findings emphasize the need for tailored training protocols that address sport-specific demands, integrating strength, flexibility, and endurance.

Keywords: Hamstring strength, Sports performance, Injury prevention, Inter-limb asymmetry, Core endurance

Öz

Bu çalışma, futbol, yüzme, voleybol, karate, güreş ve atletizm dahil olmak üzere altı farklı spor branşında hamstring kuvveti, esneklik, core dayanıklılığı, sıçrama performansı, tek bacak köprü dayanıklılığı ve diz eklem hareket açıklığı (ROM) arasındaki ilişkileri araştırmıştır. Çalışmaya, yaşları 10–18 arasında değişen toplam 249 sporcu (144 erkek, 105 kadın) katılmıştır. Sporcuların ortalama vücut kitle indeksi (BMI) 22,6 kg/m² ve spor tecrübeleri ortalama 4,9 yıl olarak kaydedilmiştir. Regresyon analizleri, performans ve sakatlık riskinin branşa özgü belirleyicilerini ortaya koymuştur. Futbol ($R^2=0,74$, $p<0,001$) ve voleybolda ($R^2=0,71$, $p<0,001$) dominant hamstring kuvveti ve torku, squat sıçrama gibi patlayıcı hareketlerin güçlü belirleyicisi olurken, yüzmede ($R^2=0,62$, $p<0,05$) dengeli hamstring kuvveti core stabilitesi için kritik bulunmuştur. Güreşte ($R^2=0,66$, $p<0,01$) baskın olmayan hamstring kuvveti, squat sıçrama performansını etkilerken, atletizmde hamstring torku diz fleksiyon ROM'u ile anlamlı bir ilişki göstermiştir ($R^2=0,72$, $p<0,001$). %10'u aşan ekstremiteler arası asimetri, artan sakatlık riski ile ilişkilendirilmiş ve simetrisinin önemini vurgulamıştır. Bulgular, spor branşına özgü ihtiyaçları ele alan, kuvvet, esneklik ve dayanıklılığı içeren bireyselleştirilmiş antrenman protokollerinin gerekliliğini ortaya koymaktadır.

Anahtar Kelimeler: Hamstring kuvveti, Spor performansı, Sakatlık önleme, Ekstremiteler arası asimetri, Core dayanıklılığı

Introduction

Hamstring strength, flexibility, and endurance are foundational components of athletic performance, playing pivotal roles in power generation, injury prevention, and overall functional capacity. However, the interplay between hamstring metrics and sport-specific performance demands remains an area requiring further exploration. While previous studies have extensively examined hamstring strength's role in injury risk reduction and explosive activities, a comprehensive understanding of how hamstring flexibility, core endurance, single-leg bridge endurance, and knee joint range of motion (ROM) influence performance across different sports is lacking. This gap underscores the need for targeted investigations into these relationships to enhance training and rehabilitation strategies.

Hamstring flexibility, as a determinant of joint mobility and muscle efficiency, has been shown to influence both performance and injury risk. Limited flexibility can disrupt movement patterns, increasing the likelihood of overuse injuries, particularly in sports requiring high speed running or jumping, such as football and track and field (Malliaropoulos et al., 2010). Conversely, excessive flexibility without corresponding strength can compromise muscle stiffness, impairing explosive performance in sports like volleyball (Marques, Van den Tillaar, Gabbett, Reis, & González-Badillo, 2009). Core endurance, on the other hand, provides the stability necessary for force transmission through the kinetic chain, which is critical in swimming and karate, where sustained stability is essential for optimal technique (Chaouachi et al., 2014; Ebben, Carroll, & Simenz, 2004). Despite its importance, the relationship between core endurance and hamstring function remains underexplored in the context of specific sports, such as football, swimming, volleyball, karate, wrestling, and track and field sports.

Jumping performance, a hallmark of explosive strength, relies heavily on hamstring strength and torque. Sports such as football and volleyball demand a high degree of explosive power, with imbalances in hamstring strength often leading to reduced jump height and increased injury risk during dynamic actions (Bishop, Read, Chavda, & Turner, 2016; Hewett, 2004). Similarly, the single-leg bridge endurance test, which assesses hamstring endurance and inter limb strength symmetry, has been identified as a valuable predictor of performance in sports requiring prolonged muscular contractions (Freckleton, Cook, & Pizzari, 2014). Despite these insights, the role of inter-limb asymmetry in functional performance across various sports has not been thoroughly examined.

Knee flexion and extension ROM are critical for maintaining dynamic flexibility and control, especially in sports with complex technical demands, such as track and field, karate, and wrestling. Limited ROM can hinder efficient movement patterns and increase the risk of compensatory injuries, while optimal flexibility enables athletes to perform complex maneuvers and maintain stability during high-intensity actions (Kay & Blazevich,

2012; Malliaropoulos et al., 2010). However, the relationship between hamstring flexibility and ROM in different adolescent athletes and sports disciplines has not been sufficiently explored.

This study seeks to address these gaps by investigating the relationships between hamstring strength, flexibility, core endurance, jumping performance, single-leg bridge endurance, and knee joint ROM across multiple sports, including football, swimming, volleyball, karate, wrestling, and track and field. By adopting a sport-specific approach, this research aims to provide a nuanced understanding of how these parameters interact to influence performance and injury risk. It is hypothesized that hamstring strength and flexibility will have distinct impacts depending on the biomechanical and functional demands of each sport, with dominant leg strength being considered more critical for explosive activities, while inter-limb symmetry and endurance are regarded as more significant in stability-intensive sports. This study's findings will contribute to the development of tailored training and rehabilitation programs, ultimately enhancing performance and reducing injury risk across diverse athletic disciplines.

Methods

Research Model

This study was conducted using a prospective regression design to examine the relationships between athletes' functional and performance parameters and their predictors of athletic performance and injury risk. The study can be classified as descriptive, quantitative, and cross-sectional. To enhance the reliability of the findings, all measurements were conducted at the Exercise Physiology and Performance Laboratory of Kültahya Dumlupınar University.

To prevent physical fatigue, the tests were divided into three separate days, ensuring adequate rest periods between trials and assessments. On the first day, participants underwent a comprehensive evaluation, including demographic data, anthropometric measurements, sports history, and injury history. On the same day, knee joint range of motion (ROM) measurements and the Squat Jump Double test were conducted to assess lower limb explosive power. On the second day, core endurance was assessed using the Horizontal Trunk Flexion Test and the Wall Sit Test. Additionally, hamstring endurance was evaluated using the Single-Leg Bridge Test. On the third day, eccentric hamstring strength was measured during the Nordic Hamstring Exercise using the IVMES H-Board device. This structured testing protocol ensured a comprehensive and reliable assessment of athletes' performance and injury risk factors.

Participants

The participants in this study consisted of 249 athletes from various sports disciplines, including 144 men and 105 women. The athletes represented different sports: athletics ($n = 19$; 10 men, 9 women), karate ($n = 15$; 4 men, 11 women), soccer ($n = 116$; 93 men, 23 women), swimming ($n = 13$; 8 men, 5 women), volleyball ($n = 66$; 11 men, 55 women), and wrestling ($n = 15$; 13 men, 2 women). The participants' ages ranged from 10 to 18 years, with a mean age of 14.7 ± 2.3 years. When analyzed by sport, the mean age was as follows: athletics (14.9 ± 2.5 years, range: 10–18 years), soccer (14.2 ± 2.0 years, range: 10–18 years), wrestling (13.3 ± 1.9 years, range: 10–18 years), and karate (13.3 ± 1.3 years, range: 10–18 years). These values indicate that the distribution of ages among the sports remains within the adolescent range, with slight variations based on sport-specific participation trends. The average height of all participants was 163.2 ± 8.3 cm, and the average body mass was 52.8 ± 10.6 kg, leading to a mean BMI of 19.8 ± 2.7 kg/m². These characteristics provide an overview of the physical development of the adolescent athletes and their potential impact on sports performance. Thus, on average, participants trained for 4.9 ± 3.1 years, had 2 to 6 training frequency sessions in a week. Inclusion Criteria: To improve the relevance of the sample while acknowledging the potential heterogeneity due to the inclusion of both pre-adolescent and adolescent participants, only athletes aged between 10 and 18 years who had been engaged in sports for at least six months and trained three or more times per week were included. Furthermore, be all members the of athletes Kütahya had Youth to and be study Sports capable without Directorate of experiencing to undergoing discomfort enable the or the physical limitations researcher tests in to required order reach for to the ensure the validity and reliability of the data collected. Exclusion Criteria: The participants were excluded if they had lower limb injury within the last six months as such injuries may affect the performance metrics. Other exclusion criteria included history of surgery on the lower limbs which may alter the biomechanical function and range of motion, neurological disorders or systemic diseases such as neurological disorders or metabolic syndrome that may affect the physical well-being or bias the results. The athletes with chronic pain or musculoskeletal disorders affecting the lower extremities were also excluded if they had medical complaints or conditions that prevented them from participating in the study or which made them unfit for the physical examinations. The sample size calculations were done using G*Power software version 3.1.9.7 since it would provide enough statistical power for detecting the differences that would be of interest. The calculations were based on an anticipated medium effect size of 0.5, a significance level of 0.05, and a statistical power of 0.8. Prior to these calculations, a pilot study was conducted with 50 participants, and the results were used to refine the effect size estimation. Based on these parameters, the minimum sample size that was needed to achieve the desired level

of precision was computed to be 210 participants. To ensure that the participants' data was not lost through dropout or any other means, a total of 249 athletes were enrolled in the study, which is beyond the required sample size. This number of participants was adequate to ensure the strength of the research and allowed for analysis of sub-groups by type of sport. The design of the study and the power analysis provided a solid methodological basis for making conclusions that are robust and comparable.

Data Collection Tools

Measurement of Knee Joint Range of Motion (ROM): The functional range of motion (ROM) of the knee joint was measured to detect any pre-existing deficits in flexion and extension, as these are critical for optimal athletic performance, particularly in activities such as sprinting, jumping, and kicking. Additionally, the flexibility of the hamstring—a key determinant of knee joint ROM—was evaluated to explore its potential influence on knee function (Moltubakk, Eriksrud, Paulsen, Seynnes, & Bojsen-Møller, 2016).

Knee Flexion ROM Measurement: Participants lay prone (face-down) on an examination table for the assessment. Starting with the knee in full extension, active and passive flexion was performed while maintaining the hip in a neutral position. A digital inclinometer was aligned with the lateral midline of the tibia and tracked the movement throughout the range of motion. The maximum angle reached during both active and passive flexion was recorded. Each leg was measured twice, and the mean value was calculated for analysis.

Knee Extension ROM Measurement: To assess knee extension, participants were positioned supine (face-up) on an examination table with their hip flexed at 90°. They were instructed to actively extend the knee to the maximum angle they could achieve. Passive extension was then evaluated by carefully moving the leg further until resistance prevented additional movement. A digital inclinometer was utilized for angle measurements, ensuring consistent evaluation across both active and passive movements. Each leg was assessed twice, and the average of the measurements was calculated. These ROM assessments were instrumental in detecting asymmetries or deficits that might contribute to movement inefficiencies or an increased risk of injury in athletes.

Eccentric Hamstring Muscle Strength: Eccentric hamstring strength was assessed using the Nordic Hamstring Exercise (NHE) and the IVMES H-Bord device (IVMES, Ankara, Turkey), a validated and reliable tool (ICC = 0.90–0.97) for measuring eccentric strength (Akarçesme et al., 2024) (Figure 1.). This evaluation focused on the hamstring muscles' capacity to resist elongation under load, a crucial aspect of deceleration and injury prevention during high-intensity athletic activities. A familiarization phase was conducted to ensure proper technique, during which participants performed one set of three submaximal NHE repetitions. In the testing phase, three maximal

eccentric repetitions were completed, with a two-minute rest interval between attempts to minimize fatigue and maintain consistent performance. Participants started in an upright kneeling position with knees bent at 90°, while their ankles were secured with supports above the lateral malleoli. They were instructed to lean forward as slowly as possible, resisting the downward force with maximum effort, all while maintaining a neutral trunk and hip alignment.

To enhance accuracy, reflective markers were positioned on key anatomical landmarks, including the greater trochanter, lateral femoral condyle, and lateral malleolus. Video recordings captured at 50 Hz were used to perform angular analyses. Strict criteria were applied to ensure data quality: repetitions were excluded if hip flexion exceeded 20°, forward bending velocity was outside the range of 20–40°/s, or if participants lost control during landing or displayed excessive lumbar movement. The IVMES H-Bord device measured peak force, mean force, and inter-limb strength asymmetries for the right and left hamstring muscles during valid repetitions. The average values from three valid trials were used for further analysis, providing a comprehensive assessment of eccentric hamstring strength (Akarçesme et al., 2024).



Figure 1. Eccentric hamstring strength assessment during Nordic Hamstring Exercise using IVMES H-Bord device

Single-Leg Bridge Endurance Test: Hamstring endurance was assessed using the Single-Leg Bridge Test, a reliable and validated method for evaluating hamstring function and identifying potential injury risk (ICC = 0.85). This test is widely recognized for its relevance in predicting hamstring injuries, particularly in sports like football and athletics. Participants began in a supine position on a flat surface, with their arms crossed over their chest to minimize upper body involvement. One heel was placed on a 60 cm platform, while the opposite leg was held upright to avoid using momentum. The task required participants to repeatedly lift and lower their hips, maintaining a neutral alignment (0°) at the top of each lift, until they could no longer perform the movement correctly. Failure was defined as an inability to maintain proper form or complete another repetition without resting. To ensure accuracy, feedback was provided during the test, and the exercise was stopped if participants demonstrated improper technique, such as pelvic tilting, lateral movement, or reliance on momentum. The total number of successful repetitions was recorded for each leg, with the order of

testing between the dominant and non-dominant legs randomized. This protocol allowed for a detailed assessment of hamstring endurance, capturing potential imbalances and weaknesses (Freckleton & Pizzari, 2013).



Figure 2. Hamstring endurance assessment (Single-Leg Bridge Test)

Core Endurance Evaluation: Core endurance, a critical component for preventing lower extremity injuries (Schuermans, Van Tiggelen, Danneels, & Witvrouw, 2014; Shield & Bourne, 2018), was assessed using two validated tests: the Wall Sit Test and the Horizontal Trunk Flexion Test.

Wall Sit Test: Participants performed the test by positioning their back against a wall, with their feet shoulder-width apart and arms crossed over their chest. They slid down the wall until both hips and knees were flexed to 90° (Figure 3). The non-tested leg was elevated 3–6 inches off the ground, requiring participants to maintain balance on a single leg. The test was stopped when participants were unable to hold the position or lost their balance. The duration (in seconds) that each participant maintained the position was recorded for both legs separately. The test was performed for both the dominant and non-dominant legs, and the average duration for each leg was calculated. This assessment demonstrated strong reliability (ICC = 0.80–0.89) and provided valuable insights into lower limb strength and endurance (Bruce, Rush, Torres, & Lipscomb, 2017).



Figure 3. Core endurance assessment (Wall Sit Test)

Horizontal Trunk Flexion Test: Participants assumed a quadruped position with their shoulders, hips, and knees flexed at 90°. To ensure stability, an assistant secured the lower legs while participants extended their arms to a 90° abduction position, maintaining a horizontal posture (Figure 4). The test continued until participants were unable to sustain proper form or experienced fatigue. The duration (in seconds) was recorded, providing a measure of endurance and control. This method demonstrated strong reliability (ICC = 0.85) (Bruce et al., 2017).



Figure 4. Core endurance assessment (Horizontal Trunk Flexion Test)

Squat Jump Double: Lower limb explosive power was evaluated using the Squat Jump Double test, a well-established method for measuring vertical force production with high reliability and validity (ICC = 0.91–0.96) (McMahon, Jones, & Comfort, 2022). Participants started in a static squat position with their knees bent at 90° and their hands placed on their hips to eliminate the influence of arm movement. From this position, they executed a vertical jump with maximum effort, ensuring both feet left the ground simultaneously (Figure 5). The test was performed using the Ivmes Athlete motion-sensitive sensor, which was securely fastened to the participant's waist with a belt to maintain stability and accuracy during measurements. This advanced system captured and analyzed all movements throughout the jump. Participants completed multiple trials, and the highest vertical jump height was recorded as the result. To ensure precision, counter-movements before the jump were strictly avoided, and participants were provided with 1–2 minutes of rest between attempts to reduce fatigue. This protocol provided an accurate and reliable assessment of lower limb explosive power (Markovic, Dizdar, Jukic, & Cardinale, 2004).



Figure 5. Lower limb explosive power assessment (Squat Jump test)

Statistical Analysis

All statistical analyses were performed using SPSS version 26.0 (IBM, Armonk, NY, USA) for computation and GraphPad Prism version 9.0 for data visualization. The significance threshold was set at $p < 0.05$. Prior to analysis, data normality was evaluated using the Kolmogorov Smirnov test, and variance homogeneity was checked with Levene's test. For variables that did not follow a normal distribution, log transformations were applied, or non-parametric tests were used when appropriate. Descriptive statistics, including means, standard deviations, and ranges, were calculated to summarize the demographic and performance characteristics of participants. Multiple linear regression analyses were conducted to identify factors influencing athletic performance and injury risk. Dependent variables included performance outcomes such as squat jump height, knee range of motion (ROM), hamstring endurance, and core stability, while independent variables consisted of eccentric hamstring strength (dominant and non-dominant), inter-limb asymmetry, and demographic factors such as age, BMI, and training experience. Both forward and backward selection methods were utilized to optimize the models, retaining only predictors with significant contributions ($p < 0.05$). Adjusted R^2 values were reported to reflect the proportion of variance explained by the models. Differences between sports disciplines were analyzed using one-way ANOVA with Bonferroni post hoc tests for continuous variables. If the assumptions of normality or homogeneity of variances were not met, the Kruskal-Wallis test was applied, followed by pairwise Mann-Whitney U tests with Bonferroni adjustments. Pearson or Spearman correlation coefficients were used to examine the relationships between hamstring metrics (e.g., strength, flexibility) and functional outcomes (e.g., jump height, endurance). Correlations were categorized as weak ($r = 0.1–0.3$), moderate ($r = 0.3–0.5$), or strong ($r > 0.5$) (Cohen, 1988).

To assess inter-limb asymmetry, the percentage difference between dominant and non-dominant hamstrings was calculated using the formula 3 (Bishop, C., Read, P., Chavda, S., & Turner, A., 2016):

$$\text{Asymmetry (\%)} = ((\text{Dominant} - \text{Non-Dominant}) / \text{Average of Dominant and Non-Dominant}) \times 100$$

An asymmetry greater than 10% was used as a threshold to identify athletes at a higher risk for performance issues or injury. Effect sizes were reported to complement significant findings: Cohen's f^2 for regression models, partial eta squared (η^2) for ANOVA, and r^2 for correlations. Effect sizes were classified as small (0.02), medium (0.13), or large (0.26) following standard conventions. Subgroup analyses were performed to explore sport-specific trends. Separate regression models were created for each sport, and interaction effects between predictors (e.g., strength and flexibility) were examined using generalized linear models (GLM). Results were visualized through scatter plots with regression lines, bar graphs showing group means with

standard deviations, and heatmaps highlighting p-values across variables and sports. These visualizations facilitated the interpretation of relationships and key findings in the context of different sports disciplines.

Ethical Approval

This study received ethical approval from the Ethical Committee of Kütahya Dumlupınar University, under the decision number 12.08.2024–388.

Findings

The heatmap below illustrates the coefficient of determination (R^2) and corresponding p-values for the relationship between various hamstring strength metrics and different sports disciplines. Darker shades represent lower p-values, indicating stronger statistical significance, while R^2 values reflect the strength of the explained variance across the measured variables.

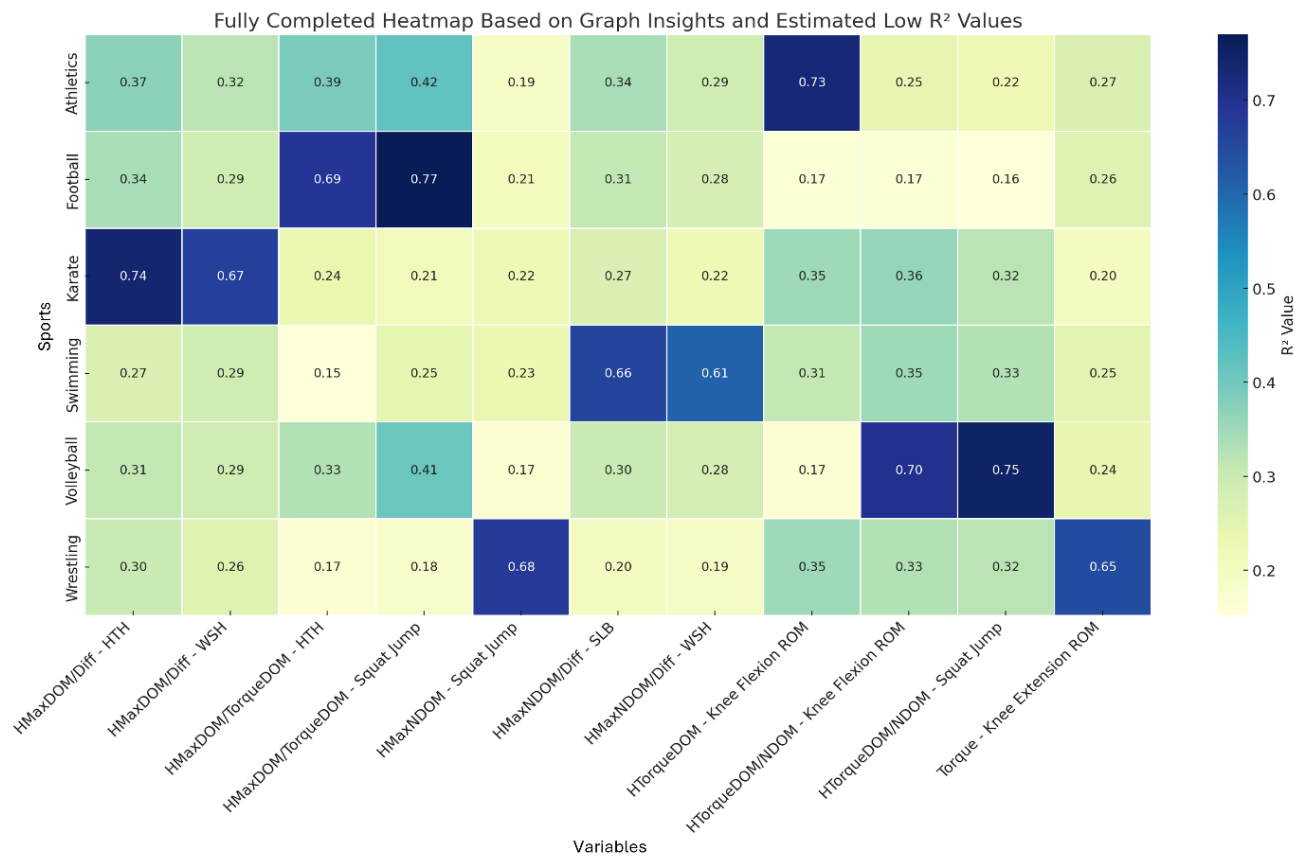


Figure 6. Heatmap of Sport-Specific Associations Between Hamstring Metrics and Functional Performance Outcomes (R^2 Values)

HMaxDOM: Maximal Hamstring Strength – Dominant Leg; HMaxNDOM: Maximal Hamstring Strength – Non-Dominant Leg; HMaxDiff: Interlimb Strength Difference; HTorqueDOM/NDOM: Hamstring Torque – Dominant/Non-Dominant Leg; HTH: Horizontal Trunk Hold; WSH: Wall Sit Hold; SLB: Single Leg Balance; ROM: Range of Motion

In volleyball, dominant and non-dominant hamstring torque values (HTorqueDOM, HTorqueNDOM) displayed strong positive correlations with Squat Jump ($R^2=0.75$, $p<0.001$) and Knee Flexion Range of Motion (ROM) ($R^2=0.70$, $p<0.01$) (Figure 6). These results emphasize the role of balanced hamstring strength in explosive jumping and lower-limb mobility, aligning with the sport's high demands for vertical power and flexibility.

In karate, dominant hamstring maximal strength (HMaxDOM) and inter-limb strength symmetry (HMaxDiff) had significant associations with Horizontal Trunk Hold (HTH) ($R^2=0.74$, $p<0.01$) and Wall Sit Hold (WSH) ($R^2=0.67$, $p<0.01$) (Figure 6), suggesting that core stabilization and endurance are influenced by hamstring strength symmetry and dominant leg stability.

In football, dominant hamstring maximal strength (HMaxDOM) and torque (HTorqueDOM) were strong predictors of Horizontal Trunk Hold (HTH) ($R^2=0.69$, $p<0.01$) and Squat Jump ($R^2=0.77$, $p<0.001$), underlining the importance of hamstring power for explosive sprinting and directional changes (Figure 6). The relationship highlights how lower-limb strength directly affects core stability and jumping ability, both critical in football.

For swimming, non-dominant hamstring strength (HMaxNDOM) and inter-limb asymmetry (HMaxDiff) significantly influenced Single Leg Bridge (SLB) ($R^2=0.66$, $p<0.05$) and Wall Sit Hold (WSH) ($R^2=0.61$, $p<0.05$) (Figure 6), demonstrating the necessity of balanced muscle engagement for optimal body positioning and endurance in the water.

In wrestling, non-dominant hamstring strength (HMaxNDOM) was a key determinant of Squat Jump ($R^2=0.68$, $p<0.01$), while hamstring torque values showed a notable effect on Knee Extension ROM ($R^2=0.65$, $p<0.05$) (Figure 6). These findings suggest that greater flexibility and strength in the non-dominant leg contribute to powerful and controlled takedown maneuvers.

Finally, in athletics, dominant hamstring torque (HTorqueDOM) was a significant predictor of Knee Flexion ROM ($R^2=0.73$, $p<0.001$), reinforcing its critical role in enhancing knee mobility for running and jumping performance (Figure 6).

Discussion

This study examined the influence of hamstring strength and flexibility on functional performance across six different sports, revealing distinct, sport-specific relationships. Our findings demonstrate that hamstring strength and flexibility are crucial components of athletic performance, but their specific roles and importance vary considerably depending on the biomechanical demands of each sport. Regression analyses revealed that various aspects of hamstring strength significantly influence functional performance in a sport-specific manner. Specifically, we found that dominant leg hamstring strength was key for explosive movements in football, balanced hamstring strength was crucial for stability and endurance in swimming, both strength and flexibility were important in volleyball, dominant leg strength and inter-limb balance were important for static stability in karate, non-dominant leg strength and flexibility were critical in wrestling, and hamstring torque was significantly associated with knee flexion range of motion in athletics. These findings highlight the need for tailored training programs that address the specific needs of athletes in different sports.

In football, the association between dominant hamstring strength (HMaxDOM and HTorqueDOM) and explosive movements like squat jump was particularly strong. HMaxDOM showed a high coefficient of determination with squat jump ($R^2=0.77$, $p<0.001$), while the combination of HMaxDOM and torque measures also revealed a strong link with squat jump performance ($R^2=0.69$). These results align with previous findings that highlighted the importance of hamstring strength for sprinting and high-velocity actions in football (Mendiguchia, Alentorn-Geli, & Brughelli, 2012). Furthermore, hamstring strength plays a major role in pelvic stability and trunk control during fast movements such as kicking and sprinting (Hewett, 2004). The dominant leg's superior contribution supports the findings of Bloomfield, Polman, and O'Donoghue (2007), who emphasized the kicking leg's force production demands. Exercises that enhance both maximal and eccentric hamstring strength—such as Nordic hamstring curls and eccentric squats—are therefore essential (Askling, Tengvar, & Thorstensson, 2013). Regular monitoring of hamstring strength throughout the season can also help reduce injury risk (Gabbett, 2016).

In swimming, balanced hamstring strength was a significant factor for core stability and muscular endurance. The difference between dominant and non-dominant leg strength (HMaxDiff) was significantly associated with wall sit performance ($R^2=0.66$, $p=0.003$), while HMaxNDOM also demonstrated a relevant association ($R^2=0.61$, $p<0.05$). Although swimming relies heavily on upper-body propulsion, hamstring strength supports streamlined positioning and propulsion through hip extension (Zhou et al., 2024). Imbalances in hamstring strength may result in compensatory trunk movements and inefficiencies. Similar conclusions were drawn by Wanivenhaus, Fox, Chaudhury, and Rodeo (2012), who recommended preseason screening of hamstring function. For swimmers, unilateral strengthening and core-focused exercises are key components of injury prevention strategies.

In volleyball, both hamstring strength and flexibility were critical. HTorqueNDOM and HTorqueDOM were significantly associated with squat jump height ($R^2=0.75$ and $R^2=0.70$, respectively; $p=0.001$). These findings support the idea that volleyball requires both high torque generation and dynamic range of motion in the lower limbs. Hamstring strength influences jump performance, while flexibility contributes to efficient movement mechanics (Hewett, 2004). Marques et al. (2009) similarly showed that hamstring stiffness affects explosive actions. As such, training plans for volleyball players should incorporate plyometrics and mobility drills such as proprioceptive neuromuscular facilitation (PNF) stretching.

In karate, static control and postural endurance were significantly associated with hamstring parameters. Dominant hamstring strength was associated with trunk hold time ($R^2=0.74$, $p=0.012$), and inter-limb asymmetry (HMaxDiff) was linked with wall sit performance ($R^2=0.67$, $p=0.002$). Karate relies heavily on balance and postural precision, particularly in stances and technique execution. Hamstring strength contributes to core stabilization and efficient force transfer (Chaouachi et al., 2014; Hewett, 2004). Karate practitioners may benefit from single-leg strength exercises, bridges, and isometric stability training.

In wrestling, non-dominant hamstring strength and flexibility were notably important. HMaxNDOM was significantly associated with squat jump performance ($R^2=0.68$, $p=0.008$), while hamstring torque also correlated with knee extension range of motion ($R^2=0.65$, $p<0.05$). These results are consistent with the sport's mechanical demands, where athletes frequently use the non-dominant leg to generate force and maintain balance during takedowns and grappling transitions (Maniar, Shield, Williams, Timmins, & Opar, 2016). A combination of non-dominant leg strengthening and hamstring flexibility is essential for optimizing wrestling performance and reducing injury risk.

Finally, in athletics, a significant association was observed between dominant hamstring torque and knee flexion range of motion ($R^2=0.73$, $p<0.001$). This reflects the need for both strength and mobility in sprinting, hurdling, and jumping

events. Strong hamstrings contribute to hip extension and knee stabilization during high-speed movements, while flexibility allows for efficient biomechanics and injury prevention (Malliaropoulos et al., 2010). Similar recommendations are made by Edouard et al. (2022) and Shield & Bourne (2018), who emphasized hamstring mobility and eccentric strength development in track-based sports.

Despite its contributions, this study has several limitations. The sample size was limited and sport-specific, potentially restricting the generalizability of the results. The cross-sectional design precludes causal inferences about the relationships between hamstring metrics and performance. Additionally, the analysis did not account for individual biomechanical variations or training history, which could influence outcomes. Future research should incorporate larger and more diverse cohorts and employ longitudinal designs to explore these relationships over time. Advanced biomechanical tools, such as motion capture and electromyography, could provide more detailed insights into hamstring function during sports activities.

Conclusions

This study highlights the critical role of hamstring strength, flexibility, and endurance in shaping sport-specific performance outcomes across diverse athletic disciplines. The findings emphasize how different sports place unique biomechanical and functional demands on the hamstring muscle group. For instance, sports requiring explosive power, such as football and volleyball, rely heavily on dominant hamstring strength, while disciplines like swimming and wrestling demand balanced strength, flexibility, and endurance for stability and efficient movement. These insights offer valuable guidance for clinicians and coaches in designing tailored training and rehabilitation protocols that address the distinct needs of athletes in their respective sports. Future research should prioritize investigating the long-term effects of sport-specific training interventions targeting hamstring function. Moreover, a deeper exploration into the interactions between hamstring metrics, such as strength symmetry, joint range of motion, and core endurance, could provide a more comprehensive understanding of their influence on performance and injury prevention. Incorporating advanced biomechanical tools and longitudinal designs could further clarify the dynamic relationships between hamstring function and sport-specific demands, ultimately enhancing athletic success and reducing injury risks.

Financial Support

No financial support was received from institutions and/or institutions during the preparation and writing of this study.

Conflict of Interest

There is no conflict of interest between the authors regarding the publication of the article.

Authors Contributions

Research Idea: EA, CS; Research Design: EA, CS; Analysis of Data: CS; Writing: EA, CS; Critical Review: EA.

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