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Understanding the Relationship Between Eccentric Hamstring Strength and Sprint Speed: The Scientific Secret to Fast Running

Eksantrik Hamstring Kuvveti ve Sprint Hızı Arasındaki İlişkiyi Anlamak: Hızlı Koşmanın Bilimsel Sırrı

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Öz: Bu çalışmanın amacı, hamstring yaralanması riskinde önemli bir faktör olarak tanımlanan eksantrik hamstring kuvveti ile maksimum sprint hızı arasındaki ilişkiyi araştırmaktır. Türkiye Süper Lig'inde mücadele eden, yaş ortalaması 25.12±3.22 olan 23 futbolcu çalışmaya dahil edildi. Sporcuların eksantrik hamstring kas kuvveti, N3 Nordic Hamstring Curl Egzersiz cihazı kullanılarak ölçüldü. Oyuncuların maksimum koşu hızları, bir GPS analisti tarafından incelenerek belirlendi. Veriler arasındaki korelasyon derecesi Spearman korelasyon testi kullanılarak analiz edilmiştir. Dominant ve nondominant taraf eksantrik hamstring kuvveti ile maksimum koşu hızı arasında anlamlı bir ilişki olmadığı bulundu. Benzer şekilde iki taraf arası eksantrik hamstring kuvvet farkı ile maksimum koşu hızı değerleri arasında da anlamlı bir ilişki olmadığı tespit edildi. *(p>0,05*). Çalışmanın sonucunda futbolcularda eksantrik hamstring kas kuvvet parametreleri ile maksimum koşu hızı arasında bir ilişki olmadığı bulundu. Bu çalışmada doğrulandığı gibi izole maksimum eksantrik hamstring kas kuvvetinin tek başına sprint sırasında yatay kuvvet üretimi için tek belirleyici parametre olmadığını göstermektedir. Ancak bu konuda yapılacak daha fazla çalışmaya ihtiyaç vardır.

Anahtar Kelimeler: *Eksantrik kas kuvveti, futbol, hamstring, sprint*

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Abstract: This study aimed to investigate the relationship between eccentric hamstring strength, identified as a significant factor in the risk of hamstring injury, and maximum sprinting speed Twenty-three football players competing in the Turkish Super League, with an average age of 25.12±3.22, were included in the study. The eccentric hamstring muscle strength of the athletes was measured using the N3 Nordic Hamstring Curl Exercise device. The maximum sprinting speeds of the players were determined by a GPS analyst. The degree of correlation between the data was analyzed using the Spearman correlation test. It was found that there was no significant relationship between eccentric hamstring strength on both dominant and non-dominant sides and maximum sprinting speed. Similarly, no significant relationship was found between the difference in eccentric hamstring strength between the two sides and maximum sprinting speed values (p>0.05). The study concluded that there is no association between eccentric hamstring muscle strength parameters and maximum sprinting speed in football players. As confirmed in this study, isolated maximum eccentric hamstring muscle strength alone does not appear to be the sole determinant parameter for horizontal force production during sprinting. However, further research is needed in this area.

Keywords: *Eccentric muscle strength, football, hamstring, sprint*

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INTRODUCTION

Football ranks among the most popular sports globally, with player activity involving various elements such as running, jogging, and sprinting. On average, an elite footballer covers a distance of approximately 10-11 km during a match, with 25-27% of this distance spent walking, 37-45% jogging, 6-8% in high-intensity running, 6-11% sprinting, and the remaining 20% on individual match activities (Dolci et al., 2018). Football performance is multifaceted, depending on several factors, including physiological, nutritional, technical, tactical, social, and psychological components (Gonçalves et al., 2014).

Among these components, sprinting is a key factor for success in football, as it plays a crucial role in both offensive and defensive actions. The ability to accelerate rapidly is a critical requirement for players across all positions, as it determines the effectiveness of many tactical movements during a match (Brűnn et al., 2022; Shah et al., 2022). Sprinting performance not only contributes to a player's individual success but also impacts the overall dynamics of the game.

Hamstring eccentric strength is particularly important in sprinting, as it plays a central role in the biomechanical demands of high-speed running (Brűnn et al., 2022). During the sprinting cycle, particularly in the swing phase, eccentric muscle contractions occur as the hamstrings decelerate the lower leg in preparation for the next stride. Sprinting in football involves both concentric and eccentric muscle activity, particularly in the lower extremities, though effective sprinting requires the coordinated activation of muscles throughout the body (Howard et al., 2018). Eccentric training has gained recognition as a critical component of speed training due to its importance in injury prevention (Van der Horst et al., 2015). Sprinting-related injuries, particularly hamstring strains, account for 57% of all hamstring injuries in football, largely due to the high eccentric forces generated during sprinting (Shah et al., 2022).

Given these considerations, eccentric hamstring strength is theorized to improve sprinting performance by enhancing both the neuromuscular response and muscle-tendon stiffness. Stronger hamstrings are better able to withstand the high tensile loads involved in sprinting, reducing the risk of injury and improving performance (Brűnn et al., 2022). Additionally, the hamstrings are key for horizontal force generation and energy absorption during high-speed running, further underscoring their importance (Morin et al., 2015; Schache et al., 2012).

Thus, the primary aim of this study is to investigate the relationship between eccentric hamstring strength, a critical factor in the risk of hamstring injuries, and maximum running speed in elite football players. It is hypothesized that there will be a significant positive correlation between eccentric hamstring strength and maximum running speed. From a physiological standpoint, eccentric strength aids in decelerating the leg during the late swing phase of sprinting, storing elastic energy for use in the subsequent propulsion phase. This improved force absorption and enhanced neuromuscular function are expected to contribute to faster sprint speeds.

Moreover, the study also explores the hypothesis that differences in eccentric hamstring strength between the dominant and non-dominant legs may significantly correlate with differences in running speed, highlighting the potential impact of strength asymmetry on performance. Finally, it is proposed that targeted eccentric hamstring strength training may significantly reduce the incidence of hamstring injuries in football players, further supporting the value of eccentric strength in both injury prevention and performance optimization.

The insights from this investigation hold significant implications for football science, particularly in identifying strategies to prevent injuries linked to hamstring strength imbalances and optimizing overall athletic performance. The originality of this study lies in its comprehensive analysis of eccentric hamstring strength and its multifaceted impact on sprint performance, leg asymmetry, and injury prevention, providing valuable guidance for coaches and athletes in elite football.

METHOD

Research Design

The study was designed using the general survey model, which is a quantitative research method, to investigate whether the eccentric hamstring strength of football players has an effect on maximal speed running.

Research Sample

The sample of the study consisted of 23 football players aged between 20-30 years playing in the Turkish Super League. Measurements were taken during the competition period of the football season. The inclusion criteria were as follows: being over 18 years of age, being an athlete in an active training season, volunteering to participate in the study, having a professional sports history of at least five years, and being an elite athlete in football. Athletes were excluded if they had a pathological condition of the lower extremities and hamstring muscle group in the previous three months, had undergone surgery on the lower extremities in the previous three months, were not actively continuing their training programme, or had taken Covid-19 in the previous six months. Prior to enrolment, all athletes were informed of the nature of the study and informed consent and assent forms were obtained from the participants. The Declaration of Helsinki was adhered to at all stages of the study.

Data Collection Instruments

Demographic and physical characteristics of the athletes (age, height, body weight, body mass index, dominant limb, year of sport) were recorded before the assessment and then performance assessments were performed. Athletes' height was recorded in metres (m) and body weight in kilograms (kg). The Body Mass Index (BMI) was determined by dividing the weight of the body by the height squared (expressed in kg/m^2). The dominant lower limb of the athletes was recorded as the side on which they kicked the ball.

Eccentric hamstring muscle strength*:* In this test, the N3 Nordic Hamstring Curl Exercise Device (N3 Easytech, San Lorenzo, Firenze, Italy) was used to assess the athletes eccentric hamstring muscle strength. The intraclass correlation coefficients (ICC) for this device are reported to be high, ranging from 0.89 to 0.95, indicating excellent reliability for eccentric hamstring strength measurements (Sannicandro et al., 2022). The footballers placed their knees on the soft pad of the device. The ankles were locked so that the locks of the device were just above the lateral malleoli.

Figure 1. Eccentric hamstring force test performed with N3®

The footballer was instructed to place the hands crossed over the chest and not to stop during the movement, but to descend as slowly as possible (Figure 1). To warm up and teach the test, a submaximal strength test was first performed for three repetitions, with a one-minute rest period to avoid the effects of fatigue. The same movement was then performed for three repetitions at maximal strength. During the test, the athlete was motivated by audible warnings. For each participant, the eccentric hamstring strength on both the dominant and non-dominant sides (measured in Newtons), as well as the percentage difference between the two, were meticulously documented.

Sprint performance: The peak running speeds of the football players were evaluated using Global Positioning Systems (GPS) by an expert data analyst. The Statsports Apex Team Series Analysis System (STATSports, Northern Ireland), known for its accuracy and reliability and with a capability of transmitting data at a rate of 15 data points per second, was employed to measure the total distance covered by the players during training sessions as well as the breakdown of distances covered at various speeds (Figure 2). The reliability of the STATSports Apex system has been validated in previous research. The intraclass correlation coefficients (ICC) for this system are reported to be high, indicating excellent reliability. For instance, Beato and de Keijzer (2019) reported ICC values ranging from 0.87 to 0.98 for peak speed measurements over various distances.

Figure 2. Statsports Apex Team Series Analysis System

This system was activated on the footballers 30 minutes prior to the commencement of the training sessions. Data captured by the Statsports system was processed using the Apex Pro Series software (Apex 10 Hz version 2.0.2.4), provided by the GPS company. This software was instrumental in calculating the duration from the beginning (warm-up phase) to the conclusion of the training sessions, based on the speed zones predefined in the program. These calculations were then exported into an Excel spreadsheet for further analysis, as cited by Beato & de Keijzer (Beato & de Keijzer, 2019).

Data Analysis

A post-power analysis was performed using GPower (GPower, ver. 3.0.10, University of Kiel, Germany) to calculate the power of this completed study. The power analysis was based on detecting a difference of 20% in maximum running speed with a significance level (alpha) of 0.05 and a power (1-beta) of 0.87. The analysis indicated that with these parameters, a sample size of 23 participants was sufficient to achieve the desired power. This calculation is consistent with findings in similar research, such as the study by Faude et al. (2012), which also used similar power analysis parameters. SPSS 26.0 (IBM SPSS Statistics 26.0, IBM SPSS® Software, US) was used for data analysis. The conformity of the data to normal distribution was assessed visually and by the Shapiro-Wilk test. The degree of correlation between the data was analysed using the Spearman correlation test. The correlation coefficient was accepted as "insignificant correlation" between "0.05-0.200", "weak correlation" between "0.201-0.400", "moderate correlation" between "0.401-0.600", "strong correlation" between "0.601-0.800", "very strong correlation" between "0.801-0.999", and "1.00" as "perfect (complete) correlation"[11]. A significance level of $p<0.05$ was used to interpret the data.

Ethical Statement

Ethical approval for the study was obtained from the Non-Drug and Non-Medical Device Research Ethics Committee of KTO Karatay University on 2023-03 with the registration number 2023/002. This study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

Table 1 displays the demographic and physical profiles of the athletes who took part in the research.

Table 1. Statistical representations of the physical characteristics of the athletes

Variables	N	Mean	S
Age (years)	23	25.12	3.22
Height (m)	23	1.77	1.15
Weight (kg)	23	78.56	5.17
Body Mass Index (BMI) (kg/m²)	23	20.23	1.42
Sport experience	23	10	2.13

Table 2 shows the descriptive statistics of the maximum velocity and eccentric hamstring strength data for the athletes in the study.

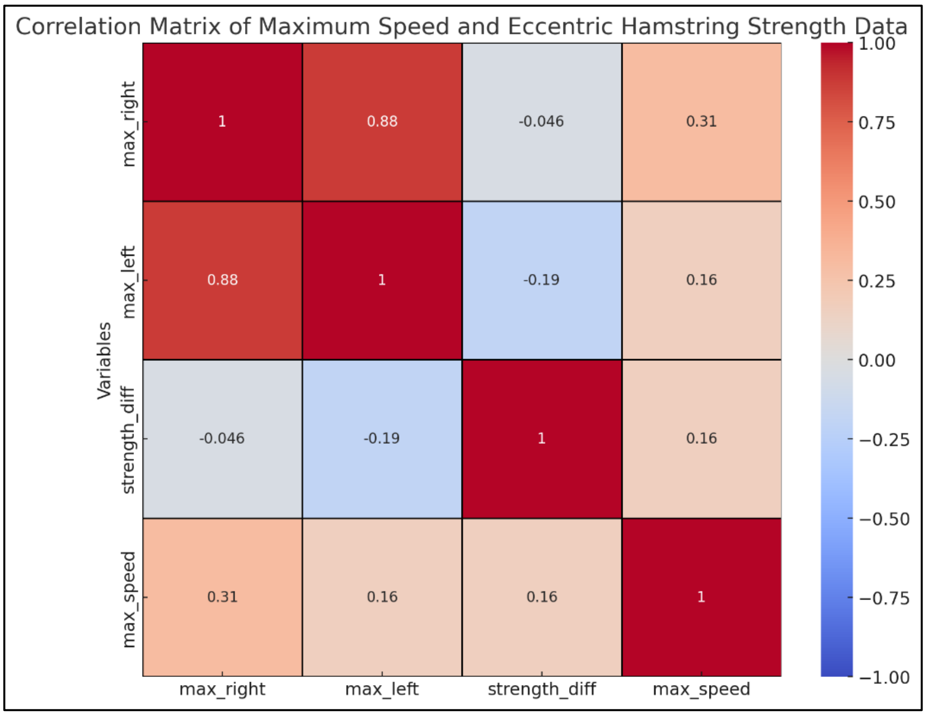
Table 2. Descriptive statistics of maximum velocity and eccentric hamstring strength data from athletes

Variables	N	Mean	S
D-Max H_{eks} (N)	23	274.04	77.15
ND-Max H_{eks} (N)	23	272.91	67.61
Strength difference (%)	23	11.41	8.64
Maximum speed (km/s)	23	33.69	1.96

D: Dominant side, ND: Non-dominant side, Max: Maximum, H_{ex}: Eccentric hamstring, N: Newton

The analysis revealed no notable correlation between the eccentric hamstring strength on the dominant versus non-dominant side and the peak running speed. In the same vein, the study determined that the variance in eccentric hamstring strength across the two sides did not significantly impact the maximum running speed metrics (p>0.05), as shown in Figure 3.

Figure 3. Correlation analysis results of maximum speed and eccentric hamstring strength. data of athletes.



Note. max_right: Maximum eccentric hamstring strength on the right side; max_left: Maximum eccentric hamstring strength on the left side; strength_diff: Strength difference between the right and left sides; max_speed: Maximum running speed (The color intensity indicates the strength and direction of the correlations, with values closer to 1 or -1 showing stronger correlations, and values closer to 0 showing weaker correlations. The significant correlations are highlighted in the heatmap.)

DISCUSSION

The findings from this study indicate that there is no meaningful relationship between the mechanical variable of sprinting, namely maximal velocity, and the eccentric hamstring strength measurements collected from football players. The fact that it is challenging to identify a factor that might be connected to speed is one rationale that could apply (Nikolaidis et al., 2016). A footballer's speed is made up of several factors that may contribute to a footballer's higher speed. The critical factors that were related in our research were weight and eccentric muscle strength. This observation can be attributed to the construction of the apparatus, where the athlete's body mass plays a crucial role in the effectiveness of performing the Nordic hamstring exercise on the N3 device. Overlooking the weight of the athlete may result in skewed outcomes for eccentric strength measurements. An athlete with a lower weight is more likely to have a lower eccentric hamstring strength than an athlete with a higher weight. Yet, it should not be assumed that an athlete with a heavier body weight necessarily possesses superior eccentric hamstring strength.

Another important limitation was the lack of intervention by the footballers and the lack of a correlation test. Correlation indicates the possible relationship between two or more variables. In addition, the body is in an upright position at maximum sprint speed, which may limit the hamstring muscles when applying horizontal forces to the ground. Consequently, the ability to rapidly apply horizontal propulsive forces to the ground could potentially also rely on other muscle groups or be determined by the technical skill of the athlete, rather than reflecting the function of the hamstring muscles themselves (Morin et al., 2015; Schache et al., 2012; Ishøi et al., 2020). This lack of correlation we found as a result of our research may seem somewhat surprising, but it is consistent with our findings in the literature. Brűnn et al. investigated the relationship between eccentric hamstring strength and sprint performance in football players and found that eccentric hamstring strength was not associated with higher speed in the 30 m sprint test (Brűnn et al., 2022). Similarly, Ishøi et al. reported no relationship between any parameter of hamstring muscle function and maximal sprint speed in their study (Ishøi et al., 2019). In a different research, Ishøi et al. conducted a comparison of sprint capabilities in a repeated sprint assessment among soccer players, distinguishing between those with and those without prior hamstring injuries (Ishøi et al., 2020).

Findings from the study indicated that there was no significant difference in mechanical sprint variables measured during the repeated 30-metre sprint test between football players with and without a history of hamstring injuries. Røksund et al. reported that football players with a hamstring injury showed a non-significant, but slightly lower sprint time (5.25 s vs. 5.35 s) during a 40-metre sprint, while there was only a small decrease in maximum theoretical sprint speed (Røksund et al., 2017). These data suggest that players with a previous hamstring injury are not severely affected in terms of maximal sprint speed. From a performance perspective, this is an important observation given that most goals in football are preceded by maximal or near maximal sprinting efforts by the player scoring or assisting the goal (Faude et al., 2012). These different observations suggest that isolated peak hamstring strength alone is not an important single determinant of horizontal force production during sprinting, as confirmed in this study.

There are several limitations to our research. Firstly, this study was conducted in healthy players with no history of hamstring injury. Secondly, the sample size was not sufficiently evenly distributed across the players' positions, so that a comparison by position could not be made. Finally, only maximal speed was assessed in sprint performance. Further studies with larger sample sizes and including other variables of sprint performance are needed.

CONCLUSION

This study provides evidence that isolated maximum eccentric hamstring muscle strength is not the predominant factor in determining horizontal force production during sprinting among football players. Despite the initial hypothesis linking eccentric hamstring strength to sprint speed, the results reveal no significant correlation. This finding suggests the complexity of sprint performance, which likely depends on a multifaceted set of physical attributes and skills. Future studies should explore a broader range of physical and biomechanical factors contributing to sprint speed in football players. This includes examining other muscle groups, overall fitness levels, and technical skills related to sprinting. To enhance the generalizability of the results, subsequent research should include a more diverse sample of players, encompassing different leagues, age groups, and playing positions. This study lays the groundwork for a more comprehensive understanding of sprint performance in football, highlighting the need for multifaceted analysis in sports science research.

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