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Araştırma Makalesi

ÇEŞİTLİ SPOR BRANŞLARINDA HAMSTRİNG KUVVETİ İLE DİKEY SIÇRAMA PERFORMANSI ARASINDAKİ İLİŞKİNİN İNCELENMESİ

INVESTIGATION OF THE RELATIONSHIP BETWEEN HAMSTRING STRENGTH AND VERTICAL JUMP PERFORMANCE ACROSS VARIOUS SPORTS DISCIPLINES

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≠ Bu çalışma, Kütahya Dumlupınar Üniversitesi Bilimsel Araştırma Projeleri (BAP) birimi tarafından 2023-46 numaralı proje kapsamında desteklenmiş.

Çeşitli Spor Branşlarında Hamstring Kuvveti ile Dikey Sıçrama Performansı Arasındaki İlişkinin İncelenmesi

ÖZ

Bu çalışma, öncelikli olarak [1] futbol, voleybol, basketbol, hentbol ve bireysel spor dallarındaki sporcularda hamstring kas kuvveti ile dikey sıçrama performansı arasındaki ilişkiyi incelemeyi ve [2] sporcuların performans göstergeleri doğrultusunda hamstring eksantrik kuvvet farklılıklarını tespit etmeyi amaçlamaktadır. Çalışmaya 18-22 yaş aralığında, haftada 3 ila 5 gün egzersiz yapan, en az 6 aydır yaralanma geçmişi bulunmayan 107 sporcu katılmıştır. Çalışmada, sporcuların dikey sıçrama performansı (İvmes Athlete) ve eksantrik hamstring kas kuvveti (iVMES H-BORD) ölçülmüştür. Verilerin analizi SPSS 23 programı kullanılarak gerçekleştirilmiştir. Normal dağılımı test etmek amacıyla çarpıklık ve basıklık değerleri +2 ile -2 aralığında kabul edilmiştir. Elde edilen verilerin normal dağılım gösterdiği belirlenmiştir. Üç veya daha fazla değişkenin karşılaştırılması için tek yönlü ANOVA testi, değişkenler arası ilişkileri incelemek amacıyla pearson korelasyon kat sayısı analizi ve değişkenlerin frekans dağılımını belirlemek için frekans analizi yapılmıştır. Verilerin tanımlayıcı istatistikleri hesaplanmış ve ortalama ile standart sapma değerleri analiz edilmiştir. Tüm analizlerde anlamlılık düzeyi $p < .05$ olarak kabul edilmiştir. Analiz sonuçlarına göre, tek taraflı (sağ-sol bacak) hamstring kuvveti ile ilgili bacakların sıçrama performansı arasında anlamlı bir ilişki olduğu gözlemlenmiştir. Futbolcuların hamstring kuvvetlerinin, diğer spor dallarındaki sporculardan belirgin şekilde daha yüksek olduğu tespit edilmiştir. Bu bulgu, futbolda yüksek hız ve patlayıcı hareket gereksinimlerinin hamstring kaslarının gelişimini teşvik edebileceğini göstermektedir. Çalışma sonuçları, farklı spor branşlarındaki sporcular arasında hamstring kuvvetindeki farklılıkları ortaya koymaktadır. Bunun yanı sıra, hamstring kas kuvvetinin dikey sıçrama performansı üzerindeki kritik rolünü vurgulamakta ve spor dalına özgü antrenman programlarının, sporcuların hamstring kuvveti ile sıçrama performansları üzerindeki etkisini göstermektedir. Gelecek çalışmaların, hamstring kuvveti dengesizliklerinin uzun vadeli yaralanma riski üzerindeki etkilerini daha ayrıntılı incelemesi önerilmektedir.

Anahtar Kelimeler: Hamstring kuvveti, dikey sıçrama, performans, futbol, voleybol, basketbol

Investigation of The Relationship between Hamstring Strength and Vertical Jump Performance Across Various Sports Disciplines

ABSTRACT

This study primarily aims to [1] investigate the relationship between hamstring muscle strength and vertical jump performance in athletes from football, volleyball, basketball, handball, and individual sports and [2] identify differences in eccentric hamstring strength based on athletes' performance indicators. A total of 107 athletes aged 18-22 years, engaging in exercise 3 to 5 days per week with no history of injuries in the past six months, participated in the study. Vertical jump performance was measured using the iVMES Athlete device, while eccentric hamstring muscle strength was assessed with the iVMES H-BORD system. Data analysis was conducted using SPSS 23. Skewness and kurtosis values between -2 and +2 were used to confirm normal data distribution. One-way ANOVA was applied for comparisons among three or more variables, Pearson correlation coefficient analysis was used to evaluate relationships between variables, and frequency analysis was conducted to determine the distribution of variables. Descriptive statistics, including means and standard deviations, were calculated, and a significance level of $p <.05$ was adopted for all analyses. The results revealed a significant relationship between unilateral (right-left leg) hamstring strength and the corresponding leg's vertical jump performance. Football players demonstrated significantly higher hamstring strength compared to athletes from other sports disciplines. This finding suggests that the demands for high-speed and explosive movements in football may promote hamstring muscle development. The study highlights the differences in hamstring strength among athletes in different sports and underscores the critical role of hamstring muscle strength in vertical jump performance. Additionally, it emphasizes the importance of sport-specific training programs in improving athletes' hamstring strength and jump performance. Future research is recommended to examine the long-term impact of hamstring strength imbalances on injury risk in greater detail.

Keywords: Hamstring strength, vertical jump, performance, soccer, volleyball, basketball

INTRODUCTION

Vertical jump is a critical measure of athletic performance. This movement depends on various factors, including the maximal force production and explosive power of the leg muscles[1]. Key factors influencing vertical jump performance include agonist-antagonist muscle coordination, symmetry of force between the extremities, the health of the hip, knee, and ankle structures, strong lumbar stabilization, effective jumping technique, and proper breathing control[2]. When these elements are combined, they directly impact an individual's jumping success[3]. Vertical jump performance is dependent on the force production of the lower extremity muscles. The higher the strength of these muscles, the greater the torque produced during the jump. During the movement, the muscles closest to the center of mass, such as the gluteus maximus and hamstrings, are activated first. Energy is then transferred sequentially to the quadriceps, gastrocnemius, and soleus muscles[4]. For a more effective vertical jump, the combined force produced by all lower extremity muscle groups is crucial. Biomechanical research shows that key muscles involved in vertical jumping include the hip extensors (Hamstrings), knee extensors (Quadriceps- Rectus Femoris), and plantar flexors (Gastrocnemius)[5]. Vertical jumping plays a significant role in sports activities or athletic performance that require high jumps[6]. Hamstring muscles support the extension of the legs and contribute to leg strength[7]. Strong hamstring muscles enable a more powerful and efficient leg extension, which enhances vertical jump ability[8]. However, hamstring muscles are also among the most injury-prone muscle groups, accounting for 54.4% of sports-related muscle injuries. This situation can negatively affect athletes' performance and continuity in the field[9].

Weakness in eccentric hamstring strength is the most frequently cited risk factor for hamstring injuries. Deficits in eccentric hamstring strength have been identified as a risk factor for both acute and recurring injuries. Therefore, assessing eccentric hamstring strength throughout the season is considered a crucial strategy for preventing injuries and improving vertical jump performance[10].

Vertical jumping is commonly used as a performance test to evaluate athletic ability, identify strengths and weaknesses in athletes, and measure the effectiveness of training programs[11].This test involves various factors, including the muscle system's force production capacity, the speed at which force can be developed, and neuromuscular coordination of the upper and lower body[12]. The literature on Nordic hamstring strength and vertical jump performance is limited and generally focuses on only a few sports[13.] Existing studies generally assess the bilateral relationship between hamstring strength and vertical jump performance[14-16]. The limited availability of measurement devices, often due to their high cost, appears to be a significant factor contributing to the scarcity of studies on Nordic hamstring strength.

Our research stands out due to its focus on measuring Nordic hamstring eccentric strength across various sports, investigating its relationship with unilateral vertical jump performance, and providing a comprehensive analysis of hamstring strength asymmetries between the dominant and non-dominant sides. By addressing these aspects, this study aims to bridge the gap in the existing literature by exploring the unilateral relationship between hamstring strength and vertical jump performance across different sports, while also identifying key performance factors and variations in eccentric hamstring strength.

METARIAL AND METHODS

Research Model

This research was conducted with students actively participating in sports at the Faculty of Sports Sciences. The sample group was selected using the cluster sampling method for the 2023-2024 academic year.

Participants

The study included 107 athletes aged between 18 and 22 who engaged in exercise 3 to 5 days per week with no history of injuries for at least 6 months. Among the participants, 46 were male and 61 were female. All participants were selected to be right-foot dominant. The athletes represented various sports disciplines: 26 in football, 17 in volleyball, 18 in basketball, and 11 in handball. Additionally, 35 athletes were involved in other sports, including athletics, archery, taekwondo, wrestling, boxing, gymnastics, judo, rugby, and kickboxing. This study was approved by the Scientific Research and Publication Ethics Committee of Kütahya Dumlupınar University, Social and Human Sciences, on 13.04.2023, with document number 159.

Data Collection Tools

The demographic characteristics of the study participants, including age, height, weight, body mass index (BMI), and dominant extremity, were recorded. The dominant lower extremity was defined as the one used for takeoff during jumping. Eccentric hamstring strength was measured during Nordic hamstring exercises using an iVMES H-BORD® device (iVMES, Ankara, Turkey) (Figure 1). Vertical jump performance was assessed using the iVMES Athlete device (Figure 2).

Measurements were conducted in the Exercise Physiology and Performance Laboratory at the university, where the temperature was maintained at 20°C and the altitude was approximately 965 meters. Additionally, measurements were taken on a flat surface covered with Taraflex. Participants completed a 10-minute warm-up protocol before the tests. The warm-up included 5 minutes of self-paced cycling on an ergometer, followed by 5 minutes of prescribed dynamic stretching and core exercises. After the warm-up, athletes first performed the bilateral vertical jump test. Each participant completed 3 trials of the bilateral vertical jump. Following this, they performed unilateral vertical jump tests for the right and left legs, with 3 trials recorded for each leg. After completing the vertical jump tests, participants proceeded to the hamstring eccentric strength assessment. Prior to the official test, participants performed one practice trial, followed by 3 trials of hamstring eccentric strength measurement.

Eccentric Hamstring Muscle Strength

The Nordic Hamstring Curl (NHC) is widely recognized as an effective and reliable method for enhancing eccentric hamstring strength. Research supports the exercise's validity and reliability for assessing eccentric hamstring strength. With the use of the H-BORD, this method has become a fast, straightforward, accurate, and dependable tool for monitoring hamstring strength and detecting imbalances[17]. In this study, the NHC exercise was conducted using the iVMES H-BORD (iVMES, Ankara, Turkey, Software version: 1.0).

Figure 1. Eccentric Hamstring Muscle Strength Test (H-Board)

For the eccentric hamstring strength assessment, athletes positioned their knees on the marked section of the pad, designated based on their tibial length. They aligned their ankles at the point where the sensor was positioned. Following a single warm-up and familiarization repetition, participants then performed a set of bilateral Nordic hamstring exercises comprising three repetitions. Each repetition began only when the athlete was fully rested and ready. Participants were instructed to gradually lean forward, lowering their upper body toward the ground with the assistance of their palms until they could no longer maintain the eccentric hamstring contraction. Continuous verbal encouragement was provided throughout each repetition to maximize effort. Repetitions were omitted from analysis if the athlete lost control during the descent or exhibited excessive hip movement.

Vertical Jump Test

Athletes' jump performances were evaluated using the Squat Jump (SQ) test with the Ivmes Athlete Jump Band motion-sensitive sensor. The device, equipped with sensors to detect all movements of the athlete during the test, was secured around the waist with a belt. The SQ test was performed three times for both bilateral and unilateral jumps, and the highest SQ height achieved during the test was recorded using this device.

Analysis of Data

In our study, statistical analyses were conducted using IBM SPSS 23. Normality tests confirmed a normal distribution, with skewness and kurtosis values between +2 and -2 deemed acceptable[18]. Arithmetic means and standard deviation were calculated. One-way ANOVA compared three or more variables, descriptive analysis provided mean and standard deviation, and pearson correlation Coefficients analysis examined parameter relationships. 0.00–0.10 Negligible correlation, 0.10–0.39 Weak correlation, 0.40–0.69 Moderate correlation, 0.70–0.89 Strong correlation, 0.90–1.00 Very strong correlation[19].Frequency analysis was also performed. Descriptive statistics, including means and standard deviations, were calculated, with a significance level set at .05.

Figure 2. Vertical Jump Test (İvmes Athlete)

RESULTS

Table 1. Mean Age and Standard Deviations of Participants by Gender

Variables	Male (n=46)	Famale (n=61)
	X±SD	X±SD
Age (year)	21,28±1,48	21,13±2,01
Sports Age (years)	4,2±2,4	5,39±3,04
Height (cm)	177,09±3,39	172,62±3,6
Weight (kg)	72,4±3,75	63,74±3,57

Table 2. Frequency Distribution by Sports Discipline

Sports Type	Frequency	Percentage (%)
Football	26	24,3
Basketball	18	16,8
Handball	11	10,3
Volleyball	17	15,9
Other Sports	35	32,7
Total	107	100

Table 2 shows the frequency and percentage distribution of participants across five different sports disciplines.

Table 3. Mean Hamstring Strength and Jump Performance

	N	X	SD
Hamstring Strength Maximal Left (N)	107	223,77	77,352
Hamstring Strength Maximal Right (N)		222,67	78,591
Hamstring Torque Left (Nm)		124,07	43,267
Hamstring Torque Right (Nm)		124,19	44,130
Maximal Hamstring Strength Different %		10,17	8,036
Two-Leg Jump Height (cm)		31,54	6,388
Right Leg Jump Height (cm)		18,87	4,133
Left Leg Jump Height (cm)		19,25	4,096

In this study, the mean hamstring strength and jump performance were assessed. Table 3 presents the performance means and standard deviations for the different variables. When examining hamstring strength values at right and left sides, minimal differences were observed between left and right leg strength. Regarding Squat Jump performance, the results indicate higher jump heights in both-leg jumps, with minimal differences observed between the right and left leg single-leg jumps.

Table 4. Correlation Between Hamstring Strength and Jump Height

Variables	Right Hamstring Strength (N)	Two-Leg Jump Height (cm)	Right Leg Jump Height (cm)	Left Leg Jump Height (cm)
Left Hamstring Strength (N)	,919**	,245*	,370**	,397**
Right Hamstring Strength (N)	1	,352**	,447**	,424**
Two-Leg Jump Height (cm)		1	,559**	,598**
Right Leg Jump Height (cm)			1	,801**
Left Leg Jump Height (cm)				1

N: Newton *p>,05 **p>,01

Table 4 presents the relationship between left and right hamstring strength and vertical jump height. The study found significant correlations between hamstring muscle strength and jump height. From a unilateral perspective, a weak positive correlation was observed between left hamstring strength and left leg jump height (r = .397; p < .01), and a moderate possitive correlation between right hamstring strength and right leg jump height (r = .447; p < .01). Additionally, weak positive correlations were found between left hamstring strength and two-leg jump height (r = .245; p <.05), and between right hamstring strength and two-leg jump height (r = .352; p < .01).

Table 5. One-Way ANOVA Results of Variables by Sports Discipline

Sub-dimensions	Sports Type	N	$\overline{X}$	SS	F	p	Difference Tukey
Hamstring Strength Maximal Left (N)	1-Football	26	274,231	88,4295	5,029	,001*	1-3 1-4 1-5
	2-Basketball	18	230,417	81,2739			
	3-Handball	11	182,945	53,7563			
	4-Volleyball	17	200,000	67,2196			
	5-Other Sports	35	207,263	59,6017			
	Total	107	223,777	77,3521			
Hamstring Strength Maximal Right (N)	1-Football	26	258,773	87,6960	2,215	,073	
	2-Basketball	18	226,094	80,7362			
	3-Handball	11	193,473	61,1763			
	4-Volleyball	17	210,135	84,5014			
	5-Other Sports	35	209,380	65,8982			
	Total	107	222,679	78,5918			
Hamstring Torque Left (N)	1-Football	26	152,177	49,0508	4,956	,001*	1-3 1-4 1-5
	2-Basketball	18	127,894	45,1054			
	3-Handball	11	101,536	29,8360			
	4-Volleyball	17	111,887	38,4492			
	5-Other Sports	35	114,246	33,8081			
	Total	107	124,077	43,2678			
Hamstring Torque Right (N)	1-Football	26	143,669	48,6360	1,985	,103	
	2-Basketball	18	125,483	44,8147			
	3-Handball	11	109,281	35,1820			
	4-Volleyball	17	116,629	46,8883			
	5-Other Sports	35	116,997	38,3465			
	Total	107	124,193	44,1309			
Maximal Hamstring Strength Difference%	1-Football	26	11,104	8,4295	,152	,962	
	2-Basketball	18	10,056	6,6175			
	3-Handball	11	9,036	5,3228			
	4-Volleyball	17	9,724	6,5046			
	5-Other Sports	35	10,131	9,8877			
	Total	107	10,178	8,0363			
Two-Leg Jump Height (cm)	1-Football	26	30,673	6,7219	,733	,571	
	2-Basketball	18	30,894	8,5073			
	3-Handball	11	29,727	3,2641			
	4-Volleyball	17	32,382	5,0605			
	5-Other Sports	35	32,683	6,2526			
	Total	107	31,542	6,3887			
Right Leg Jump Height (cm)	1-Football	26	19,915	4,6224	1,244	,267	
	2-Basketball	18	18,900	5,1047			
	3-Handball	11	16,909	2,2932			
	4-Volleyball	17	18,053	3,5770			
	5-Other Sports	35	19,120	3,8039			
	Total	107	18,879	4,1330			
Left Leg Jump Height (cm)	1-Football	26	20,627	4,7609	1,354	,255	
	2-Basketball	18	18,633	3,9328			
	3-Handball	11	17,718	3,6094			
	4-Volleyball	17	18,594	4,0359			
	5-Other Sports	35	19,360	3,7141			
	Total	107	19,255	4,0969			

In this study, the hamstring strength, jump performance, and maximal torque capacities of athletes from different sports were examined. According to the one-way ANOVA results, significant differences were found in some variables. Significant differences were observed in hamstring muscle strength between groups, $F(4, 102) = 5.03$, $p = .001$. The post-hoc Tukey test indicated significant differences between football players and athletes in handball, volleyball, and other sports. Football players exhibited higher hamstring strength compared to other sports (football-handball, $p = .006$; football-volleyball, $p = .011$; football-other sports, $p = .005$).

No significant difference was found between groups for right leg hamstring strength, $F(4, 102) = 2.22$, $p = .073$. Significant differences were found in left leg hamstring torque capacity, $F(4, 102) = 4.96$, $p = .001$. Football players showed higher torque capacity compared to handball and volleyball players (football-handball, $p = .006$; football-volleyball, $p = .015$). No significant difference was found between groups for right leg hamstring torque capacity, $F(4, 101) = 1.99$, $p = .103$.

No significant difference was found for hamstring strength imbalance, $F(4, 102) = 0.15$, $p = .962$. No significant difference was found between groups for two-leg jump performance, $F(4, 102) = 0.73$, $p = .571$. No significant difference was found between groups for right leg jump performance, $F(4, 102) = 1.24$, $p = .267$. No significant difference was found between groups for left leg jump performance, $F(4, 102) = 1.35$, $p = .255$.

These analyses reveal that football players were significantly superior in left hamstring strength and torque capacity compared to athletes in handball, volleyball, and other sports. However, no significant differences were found between groups in terms of right hamstring strength and jump performance.

DISCUSSION

The primary objective of this study was to identify the relationship between hamstring strength and jump performance in athletes from different sports and to compare performance outcomes between these disciplines. One of the key findings of the study is the significant impact of unilateral hamstring strength (right and left leg) on the jump performance of the respective legs. These results indicate that lower limb strength imbalances are directly reflected in jump performance. The importance of hamstring strength in jump performance has also been widely discussed in the literature. For instance, Demirhan et al. (2021)[20] highlighted the significance of hamstring strength in jump performance in their study on basketball and volleyball players.

In broader studies investigating the relationship between hamstring strength and jump performance, the contribution of hamstring muscles to jump performance has been notably established. Högberg et al. (2024)[21] reported that hamstring strength explained between 4.8% and 43.6% of jump performance, and in the Biodex test, relative hamstring strength accounted for 32.5% to 43.6% of vertical jump height. These findings align with the relationship between hamstring strength and jump performance observed in our study. The role of hamstring muscles in explosive power and acceleration, especially in sports requiring high-intensity efforts, is clearly demonstrated[22, 23].

Football is a sport that requires high-speed runs, rapid changes in direction, and quick accelerations. During these dynamic movements, the hamstring muscles bear a significant load, and strong hamstrings play a critical role in enhancing performance and reducing injury risk in football players[24, 25]. In our study, the hamstring strength of football players was significantly higher than that of athletes in handball, volleyball, and other sports. This finding suggests that the rapid and explosive movements required in football lead to greater development of the hamstring muscles, resulting in higher hamstring strength among football players.

Hamstring strength imbalances are also an important factor in athlete performance and injury risk. Koulouris and Connell (2007)[26] indicated that athletes with more than a 10% difference in hamstring strength between their legs had a higher risk of injury and longer rehabilitation periods. In our study, the hamstring strength difference was found to be at the 10% level, which is consistent with the threshold identified in the literature. This finding underscores the impact of hamstring strength imbalances on performance and highlights their importance for athlete health[27].

Other studies have demonstrated that hamstring strength imbalances affect overall athletic performance and are particularly pronounced in sports requiring explosive power[28, 29]. Furthermore, reducing hamstring strength imbalances has been shown to significantly decrease injury risk and optimize performance in various studies[30, 31].

The limitations of this study include the small sample size in some sports disciplines, the use of a cross-sectional design, the restriction to specific age groups and sports disciplines, and the data being collected within a limited time frame.

In conclusion, this study establishes a strong relationship between hamstring strength and jump performance, with football players exhibiting superior hamstring strength compared to athletes in other sports. These findings suggest that sport-specific training programs may have a significant impact on athletes' hamstring strength and jump performance.

RECOMMENDATIONS

- Development of Sport-Specific Training Programs: The findings highlight the significant role of hamstring strength, particularly in sports like football that require high speed and force. Therefore, it is recommended to design sport-specific training programs focused on enhancing hamstring strength and jump performance.
- Reducing Unilateral Hamstring Strength Imbalances: Our study indicates that unilateral hamstring strength imbalances directly affect performance. Training interventions aimed at reducing strength imbalances between legs could improve performance and reduce injury risk.
- Long-Term Follow-Up Studies: Considering that hamstring strength imbalances increase the risk of injury, it is recommended to conduct long-term follow-up studies to assess the effects of these imbalances. Such studies could provide valuable insights into how imbalances impact performance and injury risk over time.
- Comparative Studies on Hamstring Strength in Football and Other Sports: This study found that football players have significantly higher hamstring strength than athletes in other sports. Future research should investigate the underlying reasons

for these differences and explore the impact of sport-specific training on muscle development.

- Further Research on Hamstring Strength and Jump Performance: This study provides important findings regarding the relationship between hamstring strength and jump performance. Future studies should examine how the varying strength demands of different sports affect jump performance, contributing to the development of more tailored training programs.
- Preventive Programs for Hamstring Strength Imbalances: Since hamstring strength imbalances are known to increase injury risk, it is recommended to implement preventive exercise programs aimed at reducing these imbalances in athletes. Regular implementation of such programs throughout training seasons could help maintain balance and enhance athlete safety.

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