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Investigation of The Hamstrıng/Quadriceps Ratio, Time to Peak Torque and Joint Angle at Peak Torque Characteristics of Female Soccer Players

Kadın Futbol Oyuncularının Hamstring/Quadriceps Oranı, Pik Torka Ulaşma Süresi Ve Pik Torktaki Eklem Açısı Özelliklerinin İncelenmesi

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Abstract: It is thought that time to peak torque and joint angle at peak torque parameters provide important data for the functional evaluation of quadriceps and hamstring muscles. In the literature, it had been observed that there had been no study analyzing the specific characteristics of female soccer players. The aim of this study had been to investigate the relationship between hamstring/quadriceps (H/Q) ratio, time to peak torque, and joint angle at peak torque parameters of female soccer players. The sample group of the study had consisted of 20 female soccer players who had performed in the national women's league (3rd Division). Measurements of the soccer players' knee joints had been performed with the concentric/concentric protocol at angular velocities of 60°/s and 180°/s. The conformity of the data obtained from the soccer players to the normal distribution had been analyzed with the Shapiro-Wilk Test, and it had been determined that they had shown a normal distribution. Relationships between parameters had been analyzed with the Pearson correlation coefficient. According to the results of the analysis, it had been determined that there had been a statistically significant relationship between the non-dominant 180°/s H/Q ratio and the time to peak torque of the flexor muscle at 180°/s angular velocity, and between the dominant 180°/s H/Q ratio and the joint angle at peak torque 180°/s flexion ($p<0.05$). No relationship had been found in other isokinetic parameters ($p>0.05$). As a result, it can be said that the H/Q ratios of female soccer players are not related to functional strength parameters (time to peak torque and joint angle at peak torque) and functional performance should be evaluated with different approaches.

Keywords: Isokinetic, time to peak torque, joint angle at peak torque, female soccer players, soccer.

Özet: *Quadriceps ve hamstring kaslarının fonksiyonel olarak değerlendirilmesi için pik torka ulaşma süresi ve pik torktaki eklem açısı parametrelerinin önemli veriler sunduğu düşünülmektedir. Literatürde, kadın futbol oyuncularının söz konusu özelliklerinin analiz edildiği bir çalışmanın olmadığı görülmüştür. Kadın futbol oyuncularının hamstring/quadriceps (H/Q) oranı, pik torka ulaşma süresi ve pik torktaki eklem açısı parametreleri arasındaki ilişkinin incelenmesi bu çalışmanın amacını oluşturmuştur. Araştırmanın örneklem grubu, ulusal kadınlar liginde (3. Lig) performans sergileyen 20 kadın futbolcudan oluşmaktadır. Futbolcuların diz eklemlerine ait ölçümler, 60°/sn. ve 180°/sn. açısal hızlardaki konsantrik/konsantrik protokol ile gerçekleştirilmiştir. Futbolculardan elde edilen verilerin normal dağılıma uygunluğu Shapiro-Wilk Test ile incelenmiş ve normal dağılım gösterdikleri tespit edilmiştir. Parametreler arasındaki ilişkiler ise Pearson korelasyon katsayısı ile incelenmiştir. Analiz sonuçlarına göre, non-dominant 180°/sn. H/Q oranı ile 180°/sn. açısal hızdaki fleksör kasın pik torka ulaşma süresi arasında ve dominant 180°/sn. H/Q oranı ile 180°/sn. fleksiyon anındaki pik torka ulaşılan açı değeri arasında istatistiksel olarak anlamlı bir ilişki olduğu tespit edilmiştir ($p<0.05$). Diğer parametrelerde ise bir ilişkiye rastlanmamıştır ($p>0.05$). Sonuç olarak, kadın futbolcuların H/Q oranlarının fonksiyonel kuvvet parametreleri (pik torka ulaşma süresi ve pik torktaki eklem açısı) ile tam olarak ilişkilendirilemeyeceği ve fonksiyonel performansın farklı yaklaşımlarla değerlendirilmesi gerektiği söylenebilir.*

Anahtar Kelimeler: *İzokinetik, pik torka ulaşma süresi, pik torktaki eklem açısı, kadın futbolcu, futbol.*

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INTRODUCTION

Considering the actions involved in soccer, most of the major muscle groups of soccer players must have sufficient strength. Muscular strength is an important component of many activities such as interceptions to catch the ball and sprinting (Iri et al., 2009). Developing muscle strength and endurance makes active stabilizers of joints effective. At the same time, muscle and nervous system interaction should be developed for performance (Koz and Ersöz, 2010). One of the most reliable methods used to evaluate the strength attribute, which is an important motor skill for soccer and other sports, is isokinetic strength testing. Isokinetic strength tests are the most valid and reliable test methods that can be performed with the help of isokinetic dynamometers in the laboratory environment and that offer the opportunity to objectively evaluate the strength performance of the muscles determined in eccentric and concentric contractions (Brown, 2000). The data obtained from isokinetic dynamometers can be separately evaluated for dominant and non-dominant extremity strengths (Tasmektepligil, 2016). The strength balance between agonist and antagonist muscles is also accepted as an important determining parameter for athlete performance and injury susceptibility. It is obtained by dividing the flexor muscle (hamstring) strength by the extensor muscle strength (quadriceps) in a test performed in the same angular velocity and same contraction mode (concentric, eccentric, isometric) the strength ratio of the hamstring(H)/quadriceps(Q) muscles, which are the knee agonist and antagonist muscles (Aagaard et al., 1995). The H/Q ratio is averages between 50% and 80% throughout the entire range of knee motion (Rosene et al., 2001; Read and Bellamy, 1990).

Soccer includes many actions (shooting, jumping, etc.) that can be done with the ability of the lower extremities to product strength at high velocities. In the literature, acceleration time and time to peak torque are considered muscular parameters that provide valuable information on neuromuscular readiness to produce maximal contractions (Miller et al., 2006; Chen et al., 1994; Van Cingel et al., 2006). On the other hand, the parameters of the time to reach peak torque and the angle to reach peak torque are still seen controversial. The joint angle at peak torque is accepted as the angle of motion at which the individual reaches the peak torque in the predetermined range of motion (Bernard et al., 2012). The time to peak torque is accepted as an indicator of the explosiveness of the extremities (Kannus, 1994). The ability to reach peak torque quickly is important for most athletic skills and is thought to be a better indicator of functionality when evaluating muscular performance in

athletes (Miller et al., 2006). It has also been suggested that the time to peak torque can be used to estimate the ratio of energy cycling and fibril types (Hosking et al., 1978).

Considering the nature of soccer, which often requires explosive actions, determining the relationship of hamstring/quadriceps strength balance with the time to peak torque and the joint angle at peak torque is the focus of the study. It is important that the amount of strength that can be produced instantaneously is decisive on performance, especially in basic actions such as shooting and jumping. The aim of the study was to investigate the relationship between H/Q ratios, time to peak torque, and joint angle at peak torque of female soccer players, which were valuable for the literature.

METHODS

Research Group

The research was conducted with 20 athletes from a soccer club in the Turkish Football Federation (TFF) Women's 3rd League.

Table 1. Descriptive data of female soccer players (n=20)

	X̄±SD	Min.	Max.
Age (Year)	16.95±.94	16	18
Body Weight (kg)	55.28±8.25	44.1	79.4
Height (cm)	160.8±5.66	151	175
Body Mass Index (kg/m^2)	21.39±2.82	17.86	27.37

Participation in the study was voluntary, and each participant was given an Informed Consent Form and provided their consent. The study included soccer players who had a minimum of 3 years of license and were free from any injuries. Prior to the measurements, the participants were verbally informed and visually presented with a demonstration of the tests using an application. The research process followed the principles of the Declaration of Helsinki.

Data Collection

In order to ensure the homogeneity of the sample group in terms of training levels and physical capacities, all measurements and tests were conducted with athletes from the same team (training age= 4.2 years). The study were carried out at Ordu University Sports Sciences Research Laboratory. The ambient temperature in the laboratory was 19°C, and the humidity level was 54%. All measurements and performance tests were conducted on female athletes during the mid-season. The research group was divided into two, and measurements and tests were conducted on separate days for each group. On the first day, anthropometric measurements of all athletes were taken. On the second day, isokinetic strength tests were conducted. All measurements and tests were taken at the same time (14:00 PM), considering their biorhythms. On the day of the tests, the athletes were not involved in training, and their nutrition programs were arranged accordingly.

Height

The height of the players was determined using a stadiometer (Holtain Ltd. Crymych, UK) with an accuracy of 0.1 cm. All measurements were made in the barefoot, anatomical stance, and the head contact area of the stadiometer top plate was recorded as cm.

Body Weight

The body weights of the players were determined using a body analyzer (Jawon Body Composition Analyzer Model X-Scanplus II, Seoul, Korea) with an accuracy of 0.01 kg. Athletes were allowed to participate in the measurement with sports clothes and measurements were made in barefoot, anatomical posture.

Isokinetic Strength

Isokinetic strength tests were performed using an isokinetic dynamometer (CSMI Humac Norm, Stoughton, USA). Strength tests were performed in concentric/concentric mode, with knee flexion/extension protocol. The tests were carried out as 5 maximal repetitions in the range of motion with an angle of 0-90°, at angular velocities of 60°/s and 180°/s Before starting the tests, the procedures were explained to the athletes theoretically, and the tests were conducted after a 5-minute brief dynamic warm-up. Before starting the isokinetic tests, the dynamometer was calibrated according to the recommendations of CSMI (2003). The attachments of the device were adjusted specifically for each athlete. For the seated position knee flexion/extension protocol, the range of motion of the knee joint was set at 0-90° as described by CSMI (2003). The axis rotation of the dynamometer arm was adjusted to the level of the lateral femoral epicondyle. The lower leg attachment was fixed to the proximal part of the lateral malleolus. Body and quadriceps movement restraining belts were attached to prepare the athlete for the test. Three repetitions were made at each angular velocity value, and then the test was started by giving a 30-second rest period. Again, 30 seconds of rest was applied between angular velocities. During the tests, the athletes were verbally motivated and the torque values that the athletes could reach were recorded as Newtonmeters (Nm). The time to peak torque in milliseconds were converted to seconds, and the joint angle at peak torque was reached were recorded as degrees (°).

Data Analysis

The data obtained as a result of the measurements were analyzed with the help of a statistical package program (SPSS, IBM V21.0, Armonk, NY: IBM Corp). The conformity of the data to the normal distribution was examined using the Shapiro-Wilk Test and it was determined that they exhibited normal distribution. Then, the relationship between H/Q ratios, time to peak torque and joint angle at peak torque were examined using Pearson Correlation Analysis. Correlation (r) values were accepted as low level

between 0.00-0.30, moderate level between 0.30-0.70, and high level correlation between 0.70-1.00 (Buyukozturk, 2020). The significance value was accepted as $p<0.05$ in all statistical analyzes.

FINDINGS

Table 2. Results of isokinetic strength parameters in female soccer players (n=20).

	60°/s		180°/s	
	Dominant Leg	**Non-dominant Leg**	**Dominant Leg**	**Non-dominant Leg**
Extension				
Peak Torque (Nm)	116.75±18.67	117.75±25.69	72.20±9.52	70.50±13.66
Time to Peak Torque (sec)	.474±.08	.458±.08	.254±.06	.245±.07
Joint Angle at Peak Torque (°)	63.45±4.65	63.40±4.48	58.05±3.91	61.60±3.21
Flexion				
Peak Torque (Nm)	79.30±12.30	77.10±15.92	59.25±8.71	59.30±10.38
Time to Peak Torque (sec)	.572±.07	.587±.13	.286±.09	.276±.07
Joint Angle at Peak Torque (°)	33.05±4,61	39.05±5.06	35.70±4.83	37.20±6.83
H/Q Ratio	.68±.07	.66±.10	.82±.08	.84±.08

Nm: Newtonmeter

Results of dominant and non-dominant leg isokinetic strength parameters in female soccer players can be seen in Table 2.

Table 3. Results of the correlation analysis of the relationship between the H/Q ratios and time to peak torque of female soccer players.

			Time to Peak Torque			
			60°/s Ext.	**60°/s Flex.**	**180°/s Ext.**	**180°/s Flex.**
Dominant Leg	**60°/s H/Q**	r	-.165	.153	.208	.403
		p	.486	.521	.378	.078
	180°/s H/Q	r	-.109	-.067	-.342	-.099
		p	.647	.780	.140	.677
Non-dominant Leg	**60°/s H/Q**	r	-.101	.004	-.247	-.141
		p	.673	.986	.295	.552
	180°/s H/Q	r	.004	-.022	-.214	**-.478***
		p	.985	.926	.365	.033

p<0.05, Ext: extension, Flex: flexion

When Table 3 was examined, there was no statistically significant relationship between the dominant extremity H/Q ratios of female soccer players and the time to peak torque ($p<0.05$). It was observed that there was a statistically significant relationship ($r= -.478$) between the non-dominant H/Q ratios of female soccer players and the time to peak torque, specifically between the H/Q ratio at 180°/s angular velocity and the time to peak torque of the flexor muscle at 180°/s angular velocity ($p<0.05$). No significant relationship was found between the other H/Q ratios and time to peak torque parameters in female soccer players ($p>0.05$).

Table 4. Results of the correlation analysis of the relationship between the H/Q ratios and the joint angle at peak torque of female soccer players.

			Joint Angle at Peak Torque			
			60°/s Ext.	**60°/s Flex.**	**180°/s Ext.**	**180°/s Flex.**
Dominant Leg	**60°/s H/Q**	r	.256	.307	.264	.376
		p	.276	.187	.260	.102
	180°/s H/Q	r	.191	.349	.335	**.453***
		p	.420	.132	.149	.045
Non-dominant Leg	**60°/s H/Q**	r	.277	.363	.205	.105
		p	.237	.115	.385	.660
	180°/s H/Q	r	.340	.280	-.056	-.203
		p	.142	.231	.815	.391

p<0.05, Ext: extension, Flex: flexion

In Table 4, the relationship between the H/Q ratios of female soccer players and the joint angle at peak torque is analyzed. For the dominant extremity, a statistically significant relationship ($r = .453$) was observed between the H/Q ratio at 180°/s and the joint

angle at which peak torque was reached during flexion. No statistical correlation was found between the other isokinetic parameters ($p>0.05$).

DISCUSSION AND CONCLUSION

The study was carried out to determine the relationship between hamstring/quadriceps ratio, time to peak torque and joint angle at peak torque in female soccer players. The angular velocities in this study were determined considering the requirements of soccer. For the evaluation of the athletes' maximal strength performance, an angular velocity of 60°/s was preferred. For assessing the explosive strength property required for instantaneous explosive actions within soccer, an angular velocity of 180°/s was chosen. As many actions in soccer (such as passing, shooting, etc.) occur in the sagittal plane, flexion/extension measurements in the seated position were preferred in isokinetic dynamometry. According to the findings obtained in the study, it is seen that the amount of strength produced by the non-dominant extremity (117.75 ± 25.69 Nm) by female soccer players at an angular velocity of 60°/s is higher than that of the dominant extremity (116.75 ± 18.67 Nm). Brígido-Fernández et al. (2022) conducted a study with professional female soccer players and found that the athletes' 60°/s flexion peak torque values were determined as 83.29 ± 14.5 (Nm), and their extension peak torque values were 154.02 ± 23.39 (Nm). In the same study, the athletes' 180°/s flexion peak torque values were found to be 57.60 ± 11.03 (Nm), and their extension peak torque values were determined as 93.17 ± 14.18 (Nm). It is observed that the strength values obtained by them are higher than the strength values of the female soccer players in this study. The performance difference between them is thought to be attributed to the level of the league. In the study conducted by Andrade et al. (2021) with male U18 soccer players, it is observed that the athletes' dominant extensor peak torque values at 60°/s were determined to be 146.5 ± 28.3 (Nm), and their non-dominant extensor peak torque values at 60°/s were found to be 145.2 ± 32.0 (Nm). When looking at the dominant extremity flexor peak torque values at 60°/s, it is observed that they were able to product 81.8 ± 16.1 (Nm), and when looking at the non-dominant extremity flexor peak torque values at 60°/s, they were able to product 78.8 ± 16.5 (Nm) of strength. Comparing these findings with the data obtained in this study, it can be said that male U18 soccer players are able to product more strength with their extensor muscles, but the strength performance of the flexor muscle groups showed similarities. In the study conducted by Diker et al. (2022) with male U18 soccer players, it is observed that the athletes were able to product higher torque than the female soccer players in both 60°/s and 180°/s angular velocities in this study. It is suggested that this performance difference may be attributed to gender or training level.

It was determined that female soccer players had an H/Q balance of .68 ± .07 for the dominant extremity and .66 ± .10 for the non-dominant extremity at an angular speed of 60°/s When the values obtained at the angular velocity of 180°/s were examined, it was determined that the H/Q balance was .82 ± .08 for the dominant extremity and .84 ± .08 for the non-dominant extremity. In a compilation study conducted by Kellis and Baltzopoulos (1995) by examining many studies in the literature, it is seen that they describe the level of .60 for the H/Q ratio as "normal", and interpret the values below this ratio as a sign of muscular asymmetry. Considering the obtained H/Q ratios in this study, it can be stated that the female soccer players in this study have a normal level of muscle balance. At the same time, these results show that there is no risk of injury due to muscular asymmetry in female soccer players participating in the study. Kellis and Baltzopoulos (1995) stated in their review that the H/Q ratio increased with stepping up in angular velocity in general. The data obtained in this study also support this. With the increase in angular velocity, there is an increase of 20.58% in the dominant extremity and 27.27% in the non-dominant extremity. Brown (2000), states that strength and speed are inversely proportional, and the amount of torque that can be produced will decrease with increasing angular velocity. In this study, it can be said that the positive H/Q ratio change associated with the increase in angular velocity is due to the decreased torque in the quadriceps muscle due to the increase in angular velocity. Quadriceps, which is the extensor muscle, exhibited a torque decrease of 38.15% in the dominant extremity and 40.12% in the non-dominant extremity due to the increase in angular velocity. The hamstring, which is the flexor muscle, showed a torque decrease of 25.28% in the dominant extremity and 23.08% in the non-dominant extremity due to the increase in angular velocity. In the study conducted by Brígido-Fernández et al. (2022) with professional female soccer players, the athletes' 60°/s H/Q ratios were determined to be .54 ± .07, and their 180°/s H/Q ratios were found to be .57 ± .09. It is observed that the H/Q ratios of the female soccer players in this study are higher. Risberg et al. (2018), in their study with female soccer players, showed that soccer players were 60°/s they determined the dominant H/Q ratios in angular velocity as .59 ± 7.5 and the non-dominant H/Q ratios as .58 ± 8.0. Although it is seen that the rates determined in this study are higher, it can be said that the H/Q ratios in the study in question are also within the range considered normal. It is known that soccer players with a history of injury from the knee area or thigh muscles were not included in both studies. The difference is thought to be due to the training levels of the athletes or the physiological development differences depending on the age of the sport. At the same time, it is thought that the average peak torque values of the athletes in the mentioned study are higher than the athletes in this study and that the peak torque value they can reach especially in the extension phase may be effective on the H/Q ratio. In the study conducted by Andrade et al. (2021), it is observed that the 60°/s H/Q ratios of male U18 soccer players were .56 ± 6.60 in the dominant extremity and .54 ± 5.77 in the non-dominant extremity. It has been determined that the H/Q ratios in this study were higher. In the study conducted by Diker et al. (2022), it is observed that male U18 soccer players had H/Q ratios of .67 ± 5.4 at 60°/s angular velocity and .67 ± 9.0 at 180°/s angular velocity. While the H/Q ratios at 60°/s angular velocity were similar to those of the female soccer players in this study, the muscle balance at 180°/s angular velocity was found to be higher in this study. Steffen et al. (2008), determined the H/Q ratios of soccer players with both concentric (con) and eccentric (ecc) contraction protocols in their study with female soccer players aged 16-18. It is seen that the traditional (con/con) H/Q ratios of the athletes at 60°/s angular velocity are .61 ±

7.9, while the functional (ecc/con) H/Q ratios are .56 ± 8.3. It can be said that the values obtained from both traditional and functional determination methods are lower than the rates in this study. Considering that the average age of the soccer players constituting the sample groups in both studies is similar, it is thought that this differentiation may be due to the competition levels of the athletes. It is known that the soccer players forming the sample group in question in the study were determined from sports high schools and participated in the research. The sample group in this study consists of soccer players performing in the National 3rd. League. In a study conducted by Maciel et al. (2020), analyzing the isokinetic profiles (60°/s) of professional soccer players according to their positions, it was observed that forwards had the highest H/Q ratio (.60 ± 11.89), while side-back players had the lowest H/Q ratio (.50 ± 10.41). In this study, the H/Q ratio of the female soccer players in the sample group higher than the players in that study. In the study conducted by Coratelle et al. (2014) with amateur soccer players, the dominant lower limb 60°/s conventional H/Q ratios of the soccer players showed similarity to this study (.61 ± 0.07). However, the H/Q ratios of amateur soccer players at an angular velocity of 180°/s were lower than those of the female soccer players in this study (.67 ± 0.07). In the study of Barcelos et al. (2018), with female futsal players, the dominant H/Q ratios of the athletes at 60°/s angular speed were determined as .53 ± 8.4 and the non-dominant H/Q ratios as .55 ± 10.9. It is seen that the rates in the mentioned study are lower than this study. Although the extension peak torque values obtained in the study were higher than this study (140.25 ± 25.34 Nm), the flexion peak torque values (75.7 ± 17.8) were similar to the values in this study. In the study of Vargas et al. (2020), with female soccer players, it was determined that the players in the U17 age group were 60°/s dominant H/Q ratios were .54 ± 5.63 and non-dominant H/Q ratios were .53 ± 4.02. It was determined that the H/Q ratios of the athletes were lower than the ratios in this study. It is not known whether the soccer players in the aforementioned study have a history of injury. The fact that the athletes in this study did not have a history of injury in the knee or thigh region suggests that the difference may be due to this reason.

In the data obtained in the study, it was determined that the H/Q ratio increased as the angular velocity increased. This finding is similar to many studies in the literature (Steffen et al., 2008; Struzik et al., 2018; Andrade et al., 2012; Ermiş et al., 2019; Yılmaz et al., 2016).

When the time to peak torque of female soccer players is examined, it has been determined that the time to peak torque decreases as the angular velocity increases. According to Miller et al, the time to peak torque is an important parameter that can be used in the functional evaluation of performance (Miller et al., 2006). When the literature is examined, it is seen that the number of studies examining the time to peak torque of female soccer players is quite limited. Rozzi et al. (1999), in their study with female soccer players, found that the extensor muscles (quadriceps) reached peak torque in 371.88 ± 154.67 milliseconds at 180°/s angular velocity, and the flexor muscles (hamstring) reached peak torque in 220.63 ± 51.83 milliseconds. In this study, it was determined that the extensor muscles of the soccer players reached peak torque in the dominant extremity in .254 ± .06 seconds and in the non-dominant extremity in .245 ± .07 seconds, while the flexor muscles reached the peak torque in the dominant extremity in .286 ± .09 seconds and in the non-dominant extremity in .276 ± .07 seconds. It is thought that the difference may be due to muscle fiber type distributions. The faster physiological response to the contraction potential suggests that Type II fibril distribution may be higher in the athletes in this study. In the position-based study conducted by Maciel et al. (2020), it was found that among the players tested at an angular velocity of 60°/s, forwards reached the time to peak torque of extensor muscles the fastest (390.00 ± 95.00 milliseconds), while goalkeepers reached it the slowest (470.00 ± 136.21 milliseconds). In terms of flexor muscles, goalkeepers reached the time to peak torque the fastest (397.14 ± 156.61 milliseconds), while central attacking midfielders reached it the slowest (503.94 ± 172.07 milliseconds). Although no positional analysis was conducted in this study, it can be said that the time to peak torque values show similarity to the findings of the mentioned research. In the study of Scattone-Silva et al. (2012) with elite male karate players, it was determined that the dominant and non-dominant extremities of the athletes were 60°/s It is seen that they reach the peak torque at the moment of extension at angular velocity in .428 ± .051 seconds and .430 ± .099 seconds, respectively. At the moment of flexion, it was determined that they could reach peak torque in .510 ± .095 seconds and .513 ± .120 seconds, respectively. Although it is a different branch, it is seen that the data obtained are similar to this study.

In the measurements, it was determined that the soccer players reached peak torque at an average angle of 61° in the extension phase, and peak torque production at an average angle of 36° in the flexion phase. In the study by Maciel et al. (2020), it was observed that among the soccer players tested at an angular velocity of 60°/s, goalkeepers reached the joint angle at peak torque for extensor muscles at the earliest angle (60.14 ± 8.57°), while forwards reached it at the latest angle (66.00 ± 6.50°). Regarding the flexor muscles, it was determined that forwards reached the joint angle at peak torque at the earliest, while central attacking midfielders reached it at the latest angle (37.92 ± 10.23°). The joint angle at peak torque values of the female soccer players in this study seem to show similarity to the findings of the mentioned research. Coratelle et al. (2014) found that in amateur soccer players, the joint angle at peak torque for the dominant lower extremities at 60°/s was 68.0 ± 5.2° for quadriceps (extensor muscle), while it was 30.6 ± 6.6° for hamstring (flexor muscle). It was determined that the joint angle at peak torque for quadriceps at 180°/s was 60.9 ± 4.3°, while the joint angle at peak torque for hamstring was 43.5 ± 6.5°. The findings of amateur soccer players show similarities with the female soccer players in this study. In the study of Cagdanlioglu and Ozdal (2020) with sedentary individuals, it was determined that the peak torque reaching angles of the participants at 60°/s angular velocity of extension were 67.29 ± 13.56° and that they reached peak torque at the joint angle of 40.57 ± 9.73° at flexion has been done. It is seen that they reach the peak torque value at the joint angle of 57.07 ± 4.97° at the angular speed of 180°/s, and at the joint angle of 37.00 ± 9.22° at the flexion moment. In the study conducted by Cramer et al. (2007) with male and female participants who do sports recreationally, the average angle of reaching the peak torque at an angular velocity of 60°/s was determined as 66.5° for female participants. It is seen that the men in the same study reached the peak torque at the joint angle of 61.1°.

In conclusion, it can be said that the H/Q ratios of female soccer players are not related to both the time to peak torque and the joint angle at peak torque. The fact that the sample group in the study did not have muscular asymmetry raises curiosity about the functional isokinetic parameters of a sample group with asymmetry (such as after injury).

SUGGESTIONS

In the future, studies can be conducted to evaluate the functional strength performances (acceleration, time to peak torque and joint angle at peak torque, etc.) of athletes with muscular asymmetry.

Ethics Text

During the research process of this article, journal writing rules, publication principles, research and publication ethics rules, journal ethics rules were followed. Responsibility for any violations that may arise regarding the article belongs to the author. Ethics Committee approval was obtained with the decision numbered 2022/102 of Ordu University Clinical Research Ethics Committee.

Conflict of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contribution Rate: In this study, the contribution rate of the first author is 60% and the contribution rate of the second author is 40%.

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GENİŞLETİLMİŞ ÖZET

Çalışmanın Amacı: Quadriceps ve hamstring kaslarının fonksiyonel olarak değerlendirilmesi için pik torka ulaşma süresi ve pik torktaki eklem açısı parametreleri önemli veriler sunmaktadır. Literatürde bu parametreler ile yapılan çalışmalara az rastlandığı bilinmektedir. Kadın futbol oyuncularının hamstring/quadriceps (H/Q) oranı, pik torka ulaşma süresi ve pik torktaki eklem açısı parametreleri arasındaki ilişkinin incelenmesi bu çalışmanın amacını oluşturmaktadır.

Araştırma Soruları: Kadın futbol oyuncularının hamstring/quadriceps oranları ve pik torka ulaşma süreleri arasında bir ilişki var mıdır?

Kadın futbol oyuncularının hamstring/quadriceps oranları ve pik torktaki eklem açıları arasında bir ilişki var mıdır?

Literatur Araştırması: Futbolun içerdiği aksiyonlar dikkate alındığında, futbolcuların büyük kas gruplarından çoğunun yeterli kuvvete sahip olması gerekmektedir. Kas kuvveti, top kapmak için yapılan müdahaleler ve sprint gibi birçok aktivitenin önemli bir bileşenidir (Sevinç, 2008). Kuvvet ve dayanıklılığın geliştirilmesi, eklemlerin aktif stabilizörlerini etkili kılar. Aynı zamanda performans için kas ve sinir sistemi etkileşimi de geliştirilmelidir (Koz ve ark., 2010). Kas performansını değerlendirmede kullanılan en yaygın ve güvenilir yöntemlerden biri de izokinetik dinamometrelerdir. Laboratuvar ortamında izokinetik dinamometreler ile yapılan izokinetik kuvvet ölçümleri, eksantrik ve konsantrik kasılmalarda belirlenen kasların kuvvet performansını objektif olarak değerlendirebilme olanağı sunan en geçerli ve güvenilir test yöntemleridir (Brown, 2000). Daha önceden squat ve dikey sıçrama testleri kullanılarak tespit edilebilen alt ekstremite kuvveti, yakın geçmişten itibaren izokinetik dinamometreler kullanılarak daha objektif bir şekilde belirlenebilmekte ve dinamometrelerden elde edilen veriler ile baskın (dominant) ve baskın olmayan (non-dominant) ekstremite kuvvetleri de ayrı ayrı değerlendirilebilmektedir (Taşmektepligil, 2016). Agonist ve antagonist kaslar arasındaki kuvvet dengesi de sporcu performansı ve sakatlığa yatkınlık için önemli bir belirleyici parametre olarak kabul edilmektedir. Futbol, alt ekstremitelerin yüksek açısal hızlardaki kuvvet üretebilme yeteneği ile yapılabilen birçok aksiyonu (şut, sıçrama vb.) barındırmaktadır. Literatürde, ivmelenme süresi ve pik torka ulaşma süresi, maksimal kasılmalar üretmeye nöromusküler olarak hazır olma konusunda değerli bilgiler sağlayan kassal parametreler olarak değerlendirilmektedir (Miller ve ark., 2006; Chen ve ark., 1994; Van Cingel ve ark., 2006). Diğer yandan ise pik torka ulaşma süresi ve pik torktaki eklem açısı parametreleri hala tartışmalı olarak görülmektedir. Pik torka ulaşma açısı, bireyin önceden belirlenmiş olan hareket aralığında pik torka ulaştığı hareket açısı olarak kabul edilmektedir (Bernard ve ark., 2012). Pik torka ulaşma süresi ise ekstremitelerin patlayıcılık özelliğinin bir göstergesi olarak kabul edilmektedir (Kannus, 1994). Pik torka hızlı bir şekilde ulaşabilme yeteneği çoğu atletik beceri için önemlidir ve sporcularda kassal performans değerlendirilirken, fonksiyonellik bakımından daha iyi bir gösterge olabileceği düşünülmektedir (Miller ve ark., 2006). Ayrıca pik torka ulaşma süresinin, enerji döngüsü ve fibril tipleri oranını tahmin etmek için de kullanılabileceği öne sürülmektedir (Hosking ve ark., 1978).

Yöntem: Araştırmanın örneklem grubu, ulusal kadınlar liginde (3. Lig) performans sergileyen 20 kadın futbolcudan oluşmaktadır. Futbolcuların diz eklemlerine ait ölçümler, 60°/sn. ve 180°/sn. açısal hızlardaki konsantrik/konsantrik protokol ile gerçekleştirilmiştir. Futbolculardan elde edilen verilerin normal dağılıma uygunluğu Shapiro-Wilk Test ile incelenmiş ve normal dağılım gösterdikleri tespit edilmiştir. Parametreler arasındaki ilişkiler ise Pearson korelasyon katsayısı ile incelenmiştir.

Sonuç ve Değerlendirme: Analiz sonuçlarına göre, non-dominant 180°/sn. H/Q oranı ile 180°/sn. açısal hızdaki fleksör kasın pik torka ulaşma süresi arasında ve dominant 180°/sn. H/Q oranı ile 180°/sn. fleksiyon anındaki pik torka ulaşılan açı değeri arasında istatistiksel olarak anlamlı bir ilişki olduğu tespit edilmiştir ($p<0.05$). Diğer parametrelerde ise bir ilişkiye rastlanmamaktadır ($p>0.05$). Sonuç olarak, kadın futbolcuların H/Q oranlarının fonksiyonel kuvvet parametreleri (pik torka ulaşma süresi ve pik torktaki eklem açısı) ile ilişkili olmadığı ve fonksiyonel performansın farklı yaklaşımlarla değerlendirilmesi gerektiği söylenebilir.