Isokinetic Strength of Quadriceps and Hamstring Muscles in Soccer Players Playing in Different Leagues

Farklı Liglerde Oynayan Futbolcularda Kuadriseps-Hamstring Kasların İzokinetik Kuvvetleri

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ABSTRACT Objective: Soccer requires high muscular performance on legs. The quadriceps and hamstring muscle strength are important during the running, kicking and stabilizing of knee. Isokinetic strength evaluation is common in the sports medicine. Muscle strength imbalances contribute to knee injuries. The aim of this study was to compare the concentric and eccentric isokinetic quadriceps and hamstring muscle strength among the professional soccer players according to their playing league. **Material and Methods:** One hundred forty five professional soccer players in concentric (1st league n= 74, 2nd league n= 51, 3rd league n= 20) and 130 players in eccentric test (1st league n= 59, 2nd league n= 51, 3rd league n= 20) participated in this study. Concentric and eccentric strength of quadriceps and hamstring in both legs was assessed using a Biodex at 60º/s (Peak torque, hamstring quadriceps ratio). Analysis of variance (ANOVA) was applied for each dependent variable. Paired-t test was used in each group to examine differences between dominant and non-dominant leg in PT values. A criterion level of $p< 0.05$ was selected for all analyses. **Results:** Concentric and eccentric quadriceps and hamstring muscle strength were different between the leagues. Concentric and eccentric strength values of quadriceps in both legs were higher in the 1st league than 2nd-3rd league ($p< 0.05$). Concentric hamstring and ratio values in both legs were higher in the 1st league than 2nd -3rd league ($p< 0.05$). Eccentric hamstring and ratio values were found higher in the 2nd league than the others ($p< 0.05$). **Conclusion:** The results showed that the muscle strength of players can be related to their playing league because soccer teams have different strength training programs. Specific eccentric exercises for quadriceps and hamstring muscle should be supported into the soccer player's training program.

Key Words: Soccer; league; isokinetic; concentric; eccentric; muscle strength

ÖZET Amaç: Futbol bacaklarda yüksek kassal performans gerektirir. Kuadriseps-hamstring kas kuvveti koşma sırasında, topa vuruş sırasında ve dizin stabilizasyonu için önemlidir. İzokinetik kuvvet değerlendirmeleri spor hekimliğinde yaygın olarak kullanılır. Kas kuvveti dengesizlikleri diz yaralanmalarına neden olur. Çalışmanın amacı, profesyonel futbol oyuncularının oynadıkları liglere göre konsentrik ve eksentrik izokinetik kuadriseps ve hamstring kas kuvvetlerini karşılaştırmaktır. **Gereç ve Yöntemler:** Bu çalışmaya, konsentrik teste 145 profesyonel futbol oyuncusu (1. lig n= 74, 2. lig n= 51, 3. lig n= 20) ve eksentrik teste 130 profesyonel futbol oyuncusu (1. lig n= 59, 2. lig n= 51, 3. lig n= 20) katılmıştır. Her iki bacak kuadriseps ve hamstring konsentrik ve eksentrik kas kuvvetleri 60º/s hızda Biodex izokinetik dinamometre kullanılarak değerlendirilmiştir (pik tork, hamstring/ kuadriseps oranı). Her bağımlı değişken için varyans analizi (ANOVA) uygulanmıştır. Her grupta dominant, dominant olamayan bacak pik tork değerleri arasındaki farkı incelemek amacıyla Paired-t testi kullanılmıştır. Tüm analizler için anlamlılık düzeyi $p< 0.05$ alınmıştır. **Bulgular:** Konsentrik ve eksentrik kuadriseps ve hamstring kas kuvvetlerinde ligler arasında fark bulunmuştur. Her iki bacakta konsentrik ve eksentrik kuadriseps kuvvetleri 1. lig değerleri, 2. ve 3. lig değerlerine göre yüksektir ($p< 0.05$). Her iki bacakta konsentrik hamstring ve oran değerleri 1. lig değerleri, 2. ve 3. lig değerlerine göre yüksektir ($p< 0.05$). Eksentrik hamstring ve oran değerleri 2. ligde diğer liglerden yüksek bulunmuştur ($p< 0.05$). **Sonuç:** Çalışmanın sonuçları, futbol takımlarının farklı kuvvet antrenman programlarına sahip olduklarından dolayı futbol oyuncularının kas kuvvetlerinin oynadıkları liglerle ilişkili olduğunu göstermiştir. Futbol oyuncularının antrenmanları kuadriseps ve hamstring kaslarına özel eksentrik egzersizlerle desteklenmelidir.

Anahtar Kelimeler: Futbol; lig; izokinetik; konsentrik; eksentrik; kas kuvveti

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Quadriceps muscle plays an important role in jumping and kicking while hamstring muscles control running activities and stabilizes the knee joint during turns. The quadriceps and hamstring muscle groups are the most frequently injured muscle groups during a soccer match often causing chronic prolonged absence from training. Imbalance of strength in between agonist and antagonistic muscle groups of both legs have been defined predisposing factors of injury in soccer players.[1]

Soccer players were isokinetically characterized by a great interindividual variability of flexor and extensor muscle performances. Assuming the multifactorial origin of muscular injuries, they emphasize the importance of strength imbalances as a major risk factor. Consequently, preseason isokinetic assessment may allow a preventive approach of the injuries.[2]

Evaluation of muscle strength is often used in soccer players. Muscle strength of the lower extremities in soccer has been assessed commonly using isokinetic evaluations. Isokinetic dynamometer allows the assessment of muscle function when the joint is under constant angular velocity.[3-5] Concentric evaluation is the most frequently method used.[6] However; the muscles operating at the knee contract habitually at the eccentric mode particularly during sporting activities. The conventional (knee flexor/extensor muscle strength) ratio is commonly used to evaluate joint stability.[6,7]

Players of different leagues may have different training schedules that may affect quadriceps and hamstring strength. It is assumed that players of the first league will have intense training compared to the second and third league that may result with strengthened quadriceps and hamstring muscles.

The aim of this study was to compare the concentric and eccentric isokinetic quadriceps and hamstring muscle strength among different competition levels in the Turkish professional soccer players according to the league they play. This study may contribute to inform about the muscle strength for Turkish soccer teams directors and medical team. The condition of Turkish professional soccer players muscle strength may demonstrate on our country for literature.

MATERIALS AND METHODS

PARTICIPANTS

One hundred forty five Turkish professional male soccer players in concentric (1. league, n= 74; 2. league, n= 51; 3. league, n= 20) and 130 players in eccentric test (1. league, n= 59; 2. league, n= 51; 3. league, n= 20) participated this study. Before the test, the soccer players have been examined by their team doctors. The soccer players who had no injury were taken into the study. These data were provided with routinely preseason measurement and all soccer players participated voluntary. The soccer players, who have been only allowed by team doctor, were taken in eccentric test. Limb dominance was defined after coaches' and soccer players' reports, with regard to the leg preferentially used by soccer players in certain soccer skills. The soccer players had 112 right dominant, 33 left dominant legs in concentric test and 100 right dominant 30 left dominant legs in eccentric test. Characteristics of the soccer players by competition levels are presented in Table 1.

TABLE 1: Characteristics of the soccer players by competition levels (Mean ± SD).

	Concentric test			Eccentric test		
	1. league n = 74	2. league n = 51	3. league n = 20	1. league n = 59	2. league n = 51	3. league n = 20
Age (years)	25.3 ± 3.8*	21.7 ± 3.1	22.8 ± 3.8	24.9 ± 3.6*	21.7 ± 3.1	22.8 ± 3.7
Height (m)	1.79 ± 0.1	1.78 ± 0.1	1.78 ± 0.1	1.79 ± 0.1	1.78 ± 0.1	1.78 ± 0.1
Weight (kg)	75.4 ± 5.7	73.6 ± 7.4	72.9 ± 6.7	75.5 ± 5.9	73.6 ± 7.4	72.3 ± 8.1
BMI kg/m^2)	23.5 ± 1.3	23.4 ± 1.6	23.0 ± 1.7	23.6 ± 1.3	23.4 ± 1.6	23.0 ± 1.7

*p< 0.05.

ISOKINETIC TEST

An isokinetic dynamometer (Biodex Medical Systems, Inc., New York, USA) was used to carry out at 60 °/s in two contraction modes; concentric and eccentric. All tests were performed according to the isokinetic protocol advised by the manufacturer in order to ensure the quality and validity of testing. The dynamometer was calibrated before the study. Evaluation of each team was conducted before the competitive season. Every test session preceded by a 5 minute ergo cycle warm up (60-70 rpm) and stretching exercises (hamstring, quadriceps, gastrosoleus, and hip flexor and extensor muscles). Warm-up and stretching exercises were performed to prevent the muscle injuries and obtained the maximum strength during the tests. Subjects were tested in a sitting position with the arms folded across to the subject's chest. The mechanical axis of the dynamometer was aligned with the lateral epycondyle of femur.[5,8-10] The trunk and the thigh were stabilized with belts. The dynamometer's lever arm was positioned at the ankle. Range of motion of the concentric test was 0 to 90 degrees. The eccentric range of motion was set at 20 to 90 degrees (0 degrees corresponding to full extension). Subjects were performed three warm-up repetitions and then performed five maximum contractions for the tests. Recovery time between concentric and eccentric test was 10 minutes. After the recovery time, a test for eccentric muscle strength was performed. All subjects benefited from verbal encouragement but did not receive any visual feedback during the tests.[5,8-10] Strength was reported as the maximal peak torque (PT) and hamstring to quadriceps peak torque ratio.

STATISTICAL ANALYSIS

All data were analyzed using SPSS 13.0 (Chicago, Illinois, USA). Analysis of variance (ANOVA) was applied for each dependent variable. When significant differences were found, Tukey post-hoc analysis was applied to determine the significance of relationship of the means. Paired t-test was used in each group to examine differences between dominant and non-dominant leg in PT values. A criterion level of $p< 0.05$ was selected for all analyses.

RESULTS

ANOVA between the third leagues players in height, weight and body mass index revealed no statistical differences. The age of first league players were higher than that of the second and third leagues players ($p< 0.05$) (Table 1).

CONCENTRIC AND ECCENTRIC QUADRICEPS PT RESULTS:

Dominant Leg:

ANOVA indicated significant differences ($F_{2.142}$= 12.78, $p< 0.001$) in concentric quadriceps PT. Tukey test indicated a difference between first and second league (257.6 ± 32.9 *vs* 238.3 ± 30.2 Nm, $p< 0.005$) and also between first and third league players (257.6 ± 32.9 *vs* 221.9 ± 25.5 Nm, $p< 0.001$) (Figure 1). Eccentric quadriceps PT was found significantly different ($F_{2.127}$= 8.2, $p< 0.001$) with ANOVA. Tukey test indicated a difference between first and second league (210.9 ± 38.3 *vs* 190.5 ± 35.8 Nm, $p< 0.005$) and also between first and third league players (210.9 ± 38.3 *vs* 175.9 ± 36.2 Nm, $p= 0.001$) (Figure 1).

Non-dominant Leg:

At concentric quadriceps PT, ANOVA revealed significant differences ($F_{2.142}$= 16.41, $p<0.001$). Tukey test indicated a difference between first and second league (262.3 ± 38.3 vs 235.5 ± 29.3 Nm, $p<0.001$) and also between first and third league players (262.3 ± 38.3 vs 221.1 ± 24.5 Nm, $p<0.001$) (Figure 1). Eccentric quadriceps PT was found significantly different ($F_{2.127}$= 7.1, $p<0.005$). Tukey test indicated a difference between first and second league

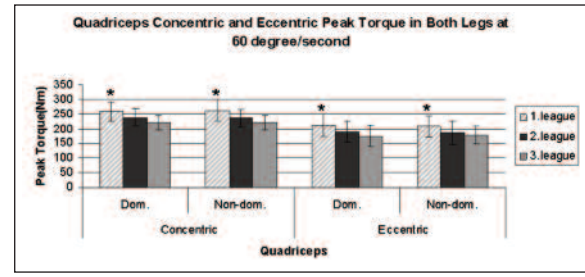

FIGURE 1: Comparison of concentric and eccentric quadriceps peak torque (Nm) in both legs at 60 degree/second for the dominant and non-dominant leg, between the three leagues (average ± standart deviations).
Dom.= Dominant leg, Non-dom.= Non-dominant leg.
* Significant difference between first and second league and also between first and third leagues.

(207 ± 36.1 *vs* 185.4 ± 39.1 Nm, p= 0.007) and also between first and third league players (207 ± 36.1 *vs* 178 ± 29.3 Nm, p= 0.007) (Figure 1).

CONCENTRIC AND ECCENTRIC HAMSTRING PT RESULTS:

Dominant Leg:

ANOVA showed a significant differences ($F_{2.142}$= 6.73, p= 0.002) concentric hamstring PT. Tukey test indicated a difference between first and third league players (141 ± 21.6 *vs* 113.2 ± 23.4 Nm, p<0.005) also between second league and third league (132.3 ± 41.4 *vs* 113.2 ± 23.4 Nm p= 0.047). ANOVA presented significant differences ($F_{2.127}$= 5.36, p= 0.006) in eccentric hamstring PT. Tukey test indicated a difference between first and second leagues (253.7 ± 92.7 *vs* 301 ± 57.4, p= 0.005) (Figure 2).

Non-dominant Leg:

ANOVA indicated significant differences ($F_{2.142}$= 6.51, p= 0.002) in concentric hamstring PT. Tukey test indicated a difference between first and third league players (134.9 ± 20.1 *vs* 106.9 ± 20.1 p= 0.001), also between second league and third league (128.2 ± 44 *vs* 106.9 ± 20.1 p= 0.026). ANOVA presented significant differences ($F_{2.127}$= 4.88, p= 0.009) in eccentric hamstring PT. Tukey test indicated a difference between first and second leagues (250.8 ± 97.1 *vs* 296.8 ± 64.4 p= 0.009) (Figure 2).

CONCENTRIC AND ECCENTRIC HAMSTRING TO QUADRICEPS PT RATIO RESULTS:

Dominant Leg:

ANOVA indicated no significant differences concentric hamstring to quadriceps PT (Hcon/Qcon) ratio. ANOVA showed significant differences ($F_{2.127}$= 9.05, p= 0.000) in eccentric hamstring to quadriceps PT (Hecc/Qecc) ratio. Tukey test indicated a difference between first and second leagues (127.1 ± 54.3 *vs* 161.5 ± 31.7, p<0.001) (Figure 3).

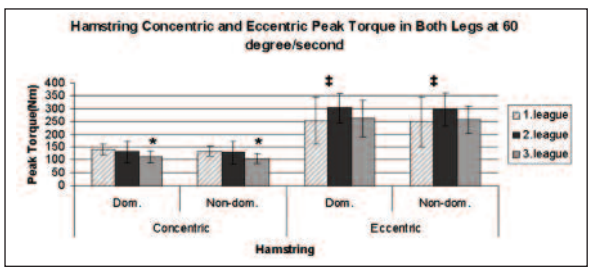

FIGURE 2: Comparison of concentric and eccentric hamstring peak torque (Nm) in both legs at 60 degree/second for the dominant and non-dominant leg, between the three leagues (average ± standart deviations). Dom.= Dominant leg, Non- dom.= Non-dominant leg,

* Significant difference between first and third league and also between second and third league.

‡ Significant difference between second and first league.

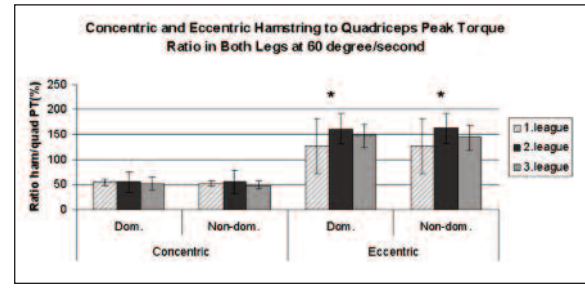

FIGURE 3: Comparison of concentric and eccentric hamstring to quadriceps peak torque ratio (%) in both legs at 60 degree/second for the dominant and non-dominant leg, between the three leagues (avarage ± standart deviations). Dom.= Dominant leg, Non-dom.= Non-dominant leg.

* Significant difference between first and second league.

Non-dominant Leg:

ANOVA indicated no significant differences concentric hamstring to quadriceps PT (Hcon/Qcon) ratio. ANOVA showed significant differences in non-dominant ($F_{2.127}$= 9.58, p= 0.000) legs eccentric hamstring to quadriceps PT (Hecc/Qecc) ratio. Tukey test indicated a difference between first and second leagues (127.2 ± 54.9 *vs* 162.9 ± 30, p<0.001) non-dominant leg (Figure 3).

COMPARISON OF DOMINANT AND NON-DOMINANT QUADRICEPS AND HAMSTRING PT AND HAMSTRING TO QUADRICEPS RATIO RESULTS IN BOTH CONCENTRIC AND ECCENTRIC MODES:

There was no difference between the dominant and non-dominant leg on the concentric and eccentric quadriceps PT in three leagues (p> 0.05) (Table 2). A significant difference was found between the dominant and non-dominant leg for the concentric hamstring PT and HcoSn/Qcon ratio in the first league players (p< 0.05) (Table 3, 4). Significant differences were not found in eccentric hamstring PT, between dominant and non-dominant legs in the other leagues (p> 0.05) (Table 3, 4).

TABLE 2: Comparison of quadriceps concentric peak torque (Nm) between dominant and non-dominant legs in three different leagues.

	Concentric				Eccentric			
Quadriceps	Dom.	Non-dom			Dom.	Non-dom		
	X ± SD	X ± SD	T	p	X ± SD	X ± SD	t	p
1. league	257 ± 32	262 ± 38	1.3	0.21	210 ± 38	207 ± 36	1.2	0.24
2. league	238 ± 30	235 ± 29	0.7	0.49	190 ± 35	185 ± 39	1.5	0.14
3. league	221 ± 25	221 ± 24	0.2	0.86	175 ± 36	178 ± 29	0.3	0.74

Dom: Dominant, Non-dom: Non-dominant leg, p< 0.05.

TABLE 3: Comparison of hamstring concentric peak torque (Nm) between dominant and non-dominant legs in three different leagues.

	Concentric				Eccentric			
Hamstring	Dom.	Non-dom			Dom.	Non-dom		
	X ± SD	X ± SD	T	p	X ± SD	X ± SD	t	p
1. league	141 ± 21	134 ± 20	3.2	0.002*	253 ± 92	250 ± 97	0.6	0.5
2. league	132 ± 41	128 ± 44	1.9	0.06	301 ± 57	296 ± 64	0.7	0.5
3. league	113 ± 23	106 ± 20	1.9	0.08	262 ± 70	255 ± <54	0.5	0.6

Dom: Dominant, Non-dom: Non-dominant leg, p< 0.05.

TABLE 4: Comparison of hamstring to quadriceps ratio (%) between dominant and non-dominant legs in three different leagues.

	Concentric				Eccentric			
Ratio	Dom.	Non-dom			Dom.	Non-dom		
	X ± SD	X ± SD	t	p	X ± SD	X ± SD	t	p
1. league	55 ± 7.3	51.5 ± 6.4	3.6	0.001*	127.1 ± 54.3	127.2 ± 54.9	0.0	0.98
2. league	56 ± 19.6	55.1 ± 22.5	0.8	0.43	161.5 ± 31.7	162.9 ± 30	0.4	0.7
3. league	51.1 ± 13.2	48.6 ± 8.8	1.7	0.1	148.4 ± 23.1	144.1 ± 24.7	0.7	0.55

Dom: Dominant, Non-dom: Non-dominant leg , p< 0.05.

DISCUSSION

Muscle strength is one of the most important variables for measuring performance in team sports in physical condition. Because of the complexity of the soccer game, it is difficult to ascertain the contributing muscle strength to the functional outcome. Talent and technical and tactical strategies are the other contributing factors.[5] Injury mechanisms consist of intrinsic and extrinsic risk factors. Intrinsic risk factors are age, career duration and previous injury, whereas extrinsic risk factors such as lack of training, levels of competition may be increase the injury risk.[4,5]

In our study, professional soccer players in three different leagues underwent pre-season isokinetic muscle testing to determine if there was any difference between the different leagues teams' players and between dominant and non-dominant legs in quadriceps and hamstring muscle groups.

According to the results of our study concentric and eccentric muscle strength was different between the three leagues players. Concentric and eccentric strength values of quadriceps were higher in the 1. league players than the 2. league and 3. league players in both legs. Concentric hamstring PT values were less in the 3. league players than the 1. leaque and 2. league players. Eccentric ham-

string PT values were higher in the 2. league players than the others. These differences can be explained by competition levels. Because different competition levels teams have different training program and increased levels of competition can provide regular training programme.

There are several studies on the association between isokinetic strength and different competition levels in the literature. Giggis et al.,[11] found that national youth Greece elite soccer players had greater isometric force than sub-elite and recreational soccer players'. Although isometric force was used to evaluate the muscle strength in this study, results of this study are similar our results.[11] The findings of our study first league soccer players' muscle strength higher than other leagues. Cometti et al. evaluated French first division (elite), second division (sub-elite), and amateurs and evaluated isokinetic concentric quadriceps and hamstring muscle strength.[12] According to the results of their study, elite players had higher hamstring torque than amateur players. Other studies showed similar findings.[6,13] In our study, 1. league players' concentric hamstring PT values were higher than the 3. league players' in both legs. On the contrary to these studies and our study; Zakas et al., could not find any differences in concentric PT values of quadriceps and hamstring within different soccer and basketball divisions.[14] In our study, 1. league players' eccentric quadriceps PT values and 2. league players' eccentric hamstring PT values were higher than the other league players. Iga et al., demonstrated that trained soccer players were stronger than untrained players in eccentric quadriceps and hamstring PT in both legs.[15] However, Chollet et al, showed no differences in eccentric quadriceps and hamstring strength between the soccer players and sedentary people.[6]

In soccer, explosive type of efforts such as starts, sprints, jumps, duels, feints and kicking are important factors for successful soccer performance. These efforts depend in more extend on the maximal strength of the lower extremities. Over emphasis on one side activities, such as kicking, jumping and landing may lead to asymmetry and dominance of one leg which in turn may cause greater than normal differences in strength.[16]

Zakas A., suggested the absence of asymmetry between the dominant and non-dominant leg concentric PT in both muscle groups.[16] The result of our study also suggests no difference between dominant and non-dominant legs for concentric quadriceps PT. However; Otzel et al., found significant differences for concentric quadriceps strength between dominant and non-dominant legs.[17] Bilateral strength differences were found in Rahnama's et al., study; the hamstring muscles of the dominant leg were weaker than those in the non-dominant leg.[18] This strength difference was apparent in both concentric and eccentric modes. In contrast, according to the findings of our study, dominant concentric hamstring PT was greater than non-dominant leg. A possible explanation for this difference is that, a differential training stimulus to the hamstring muscles between dominant and non dominant legs.

The most frequently reported strength ratio of the knee muscles was the concentric Hcon/Qcon ratio. Knapik and Ramos indicated that the Hcon/Qcon ratio varies from 50% to 62% in healthy people whereas ratios for soccer players vary from 41% and 81%. In the current study, averages of Hcon/Qcon ratio were found 55% in dominant leg and 52% in non-dominant leg.[19]

Several studies were found significant differences between elite soccer players and other groups for Hcon/Qcon ratio.[6,20,21] However; other authors showed that the Hcon/Qcon ratio was found any difference between the divisions of soccer players.[14,22] Iga et al., compared bilateral isokinetic strength characteristics of knee flexor and extensor muscles in trained junior soccer players to an untrained control group.[15] They found that trained soccer players' Hcon/Qcon and Hecc/Qecc ratio were higher in both legs of the untrained individuals. Our study showed that Hcon/Qcon ratio has no significant difference between the three leagues in both legs. However, the 2. league players Hecc/Qecc ratio was found significantly higher than other groups.

Rahnama et al., found significant differences between dominant and non-dominant legs of elite and sub-elite soccer players' Hcon/Qcon ratio.[18]

Significant difference was found between the dominant and non-dominant leg for the Hcon/ Qcon ratio of 1.league players in our study.

CONCLUSION

Our results showed that the muscle strength and agonist/antagonist PT ratio can be related to the competition level because soccer teams have different strength training programs. Muscle strength imbalances contribute to knee injuries. Specific eccentric exercises for quadriceps and hamstring muscle should be supported into the soccer player's training program. Therefore; knee injuries can be prevented.

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