

Effect of Age on Isokinetic Concentric and Eccentric Strength of Knee Muscles in Soccer Players

Futbolcularda Diz Kaslarının İzokinetik Konsentrik ve Eksentrik Kuvvetleri Üzerine Yaşın Etkisi

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ABSTRACT Objective: Soccer is widely considered to be the most popular sport in the world. Several injuries have shown that muscle strength is affected by several parameters such as height, body mass, dominant leg and age. The purpose of this study was to investigate the effect of age groups and the difference between the concentric and eccentric isokinetic peak torque values of quadriceps and hamstring muscles on dominant and non-dominant legs of men soccer players. **Material and Methods:** 102 (19.71 ± 3.8 years) soccer players participated in our study. The players were divided into four groups as 15-17 years (n= 34), 18-20 years (n= 35), 21-23 years (n= 16), 24> -years (n= 17). Isokinetic concentric and eccentric muscle strength of quadriceps and hamstring muscle groups have been measured at angular velocities of 60 degree/seconds (5 repetitions). The obtained data was analyzed using SPSS (Version 13.0; SPSS Inc.) software. One way analysis of variance was applied for each dependent variable between different age groups. Post-hoc Tukey tests were used in order to determine any significant differences between groups. Isokinetic strength values of dominant and non-dominant legs have been analyzed by using paired t-test. For all analyses, the significance level has been set as p < 0.05. **Results:** The results of our studies indicate that there is no variation between the eccentric and concentric peak torque values of four different age groups. It has been observed that the concentric peak torque hamstring values of the dominant leg are higher than the values of the non-dominant leg (p < 0.01). No difference has been encountered in eccentric peak torque values of dominant and non-dominant legs (p > 0.05). **Conclusion:** The results presented that muscle strength may remain unaffected by age. According to the results, it has been established that the concentric muscle strength value of the dominant leg is higher than that of the non-dominant leg. Future studies should be carried out with increased number of age groups and number of players.

Key Words: Soccer, age, muscle strength, isokinetic, eccentric, concentric.

ÖZET Amaç: Futbol, dünyada oldukça yaygın ve popüler bir spordur. Birçok yaralanmada kas kuvvetinin boy uzunluğu, kilo, dominant bacak ve yaş gibi parametrelerden etkilendiği görülmüştür. Bu çalışmanın amacı, dominant ve non-dominant bacaklarda kuadriseps ve hamstring kas gruplarının konsentrik ve eksentrik izokinetik "peak torque" (kuvvet) değerleri arasındaki farkı ve yaşın etkisini incelemektir. **Gereç ve Yöntemler:** Çalışmamıza 102 (19.71 ± 3.8 yıl) futbol oyuncusu katılmıştır. Oyuncular 15-17 yıl (n= 34), 18-20 yıl (n= 35), 21-23 yıl (n= 16), 24> yıl (n= 17) olmak üzere dört gruba ayrılmıştır. Kuadriseps ve hamstring kas gruplarının izokinetik olarak konsentrik ve eksentrik kas kuvvetleri 60 derece/saniyelik açılmal hızlarda beş kez tekrar edilerek ölçülmüştür. Veriler SPSS (13.0; SPSS Inc.) programı kullanılarak analiz edilmiştir. İki grup arasında her bağımlı değişken için varyans analizi uygulanmıştır. Gruplar arasındaki farkı belirlemek için Post-hoc Tukey testi kullanılmıştır. Dominant ve dominant olmayan bacak izokinetik kuvvet değerleri paired t-test ile değerlendirilmiştir. Tüm analizler için anlamlılık düzeyi p < 0.05 alınmıştır. **Bulgular:** Çalışmamızın sonuçlarında dört yaş grubu arasında konsentrik ve eksentrik kuvvet değerlerinde fark bulunmamıştır. Dominant bacak hamstring konsentrik kuvvet değerleri non-dominant bacak değerlerine göre yüksek bulunmuştur (p < 0.01). Eksentrik kuvvet değerleri arasında fark bulunmamıştır (p > 0.05). **Sonuç:** Bu sonuçlar kas kuvvetinin yaştan etkilenemeyeceğini göstermiştir. Dominant bacak hamstring konsentrik kas kuvveti değerleri non-dominant bacak değerlerinden yüksek bulunmuştur. İleri çalışmalarda futbol oyuncusu sayıları veya yaş grupları artırılarak inceleme yapılmalıdır.

Anahtar Kelimeler: Futbol, yaş, kas kuvveti, izokinetik, eksentrik, konsentrik

Soccer is one of the most popular sports which people of all ages can play. Players have to perform several combinations of movements like sudden feints, stops, starts, duels, sprints, jumps and kicking. Muscle strength is generally emphasized in preventive and rehabilitative programs for athletes. Strength testing is a routine procedure for soccer players. Isokinetic dynamometer allows the assessment of muscle function when the joint is under constant angular velocity conditions.¹⁻⁶ Generally quadriceps-hamstrings peak torque (PT), peak torque/body weight (PT/BW) values and hamstring/quadriceps (H/Q) ratio are assessed in isokinetic dynamometer analyses.

Muscle strength and mass are highly influenced by training during puberty, especially in males. Strength is generally maximal between 20 and 30 years of age. Muscle mass typically decreases by 30% between ages of 30 and 70 years.^{1,7} In fact; isokinetic muscle strength measurement values become greater as age increases in young adult.⁸ It has been reported that in general strength is affected by anthropometric parameters such as height, limb length, body mass and muscle mass. However, there has not been extensive investigation on the knee strength development with age using isokinetic dynamometer.^{1,7-9}

Asymmetries in strength between quadriceps and hamstrings muscle groups have been regarded as predisposing factors for injury in soccer players.¹⁰⁻¹⁶ The H/Q strength ratio has been used to assess knee functional ability and muscle balance. This ratio has been expressed conventionally as concentric hamstring to quadriceps strength and more recently as functional eccentric-hamstring to concentric-quadriceps strength and concentric-hamstring to eccentric quadriceps ratio.^{6,10,11,14,17,18}

One of the two purposes of this study was to evaluate the effect of age on the isokinetic concentric and eccentric muscle strength. This purpose has been accomplished through isokinetic tests. Second purpose of the study was to examine quadriceps and hamstring strength imbalance between four age groups. This examination has been conducted by the use of traditional (concentric H_{CON}/Q_{CON} and eccentric H_{ECC}/Q_{ECC} hamstring-quadriceps), and functional (eccentric-hamstring to concentric-quadriceps H_{ECC}/Q_{CON} and concentric-hamstring to eccentric-quadriceps H_{CON}/Q_{ECC}) ratios. Another purpose was to investigate the difference between the dominant and the non-dominant leg isokinetic muscle strength value of the study groups.

MATERIAL AND METHODS

SUBJECT

The study group consisted of professional players from five soccer clubs of the Premier Turkish Football League. One hundred and two elite male soccer players, mean age 19.7 ± 3.6 years were measured. The players were divided into four groups: Group 1 (15-17 years; n= 34), group 2 (18-20 years; n= 35), group 3 (21-23 years; n= 16), and group 4 ($24 \geq$; years n= 17). Physical characteristics of players are presented in Table 1. *The athletes have voluntarily participated in the study. Prior to the tests, the athletes have been examined by their team doctors and their medical condition had been approved for participation in tests. None of the players had a history of injury of the lower limbs. Lower limb dominance of the players was noted. Information on the procedure was given to players prior testing. They were asked to refrain from vigorous exercise 24 hours before testing.*

TABLE 1: Physical characteristics of players.

Group	N	Age (years)	Weight (kg)	Height(m)	BMI (kg/m ²)
		Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD
1 (15-17 years)	34	16.4 \pm 0.8	67.5 \pm 6.4	1.75 \pm 0.1	21.9 \pm 1.5
2 (18-20 years)	35	18.7 \pm 0.8	69.3 \pm 6.0	1.76 \pm 0.05	22.2 \pm 1.3
3 (21-23 years)	16	21.8 \pm 0.8	72.6 \pm 8.5	1.76 \pm 0.06	23.2 \pm 2.1
4 ($24 \geq$ years)	17	26.0 \pm 3.0	75.9 \pm 6.5	1.77 \pm 0.06	24.0 \pm 1.3

BMI: kg²/m

ISOKINETIC TESTING

Concentric and eccentric PT of the quadriceps and the hamstring muscles was measured using the Biodex System 3 isokinetic dynamometer (Biodex Medical Systems, Inc., New York, USA) at angular velocities of 60 degree/second. All tests were performed during seated position. The trunk, thigh and tibia were stabilized with straps in order to prevent extreme joint movement. Orientation of the dynamometer was kept at 0°, tilt at 0° and seat orientation at 0°. Range of motion of the knee joint was fixed from 0° to 90° (0°= fully extended knee). Axis of rotation of the dynamometer was aligned with the lateral femoral condyle.^{5,6,11,18,19} Before the testing procedure, all players warmed-up for 5 minutes on a cycle-ergometer and stretching exercises of the lower extremities (hamstring, quadriceps, gastrosoleus, and hip flexor and extensor muscles). Testing protocol consisted of three sub-maximal and five maximal concentric and eccentric repetitions of the knee extensors and flexors. *Before each test, the athletes had time to take a ten-second break to rest.* In each angular velocity, the best PT of the five test contractions was recorded for data analysis. The players had visual feedback for their moment scores on the computer and were instructed to practice as hard as possible.^{1,18,19} PT (nm), PT/BW, (nm/kg), both conventional (concentric and eccentric hamstring quadriceps H_{CON}/Q_{CON} , H_{ECC}/Q_{ECC}) and functional (eccentric-hamstring to concentric-quadriceps H_{ECC}/Q_{CON} and concentric-hamstring to eccentric-quadriceps H_{CON}/Q_{ECC} (%)) ratios were used for analyses.

STATISTICAL ANALYSIS

The data were analyzed using SPSS (Version 13.0; SPSS Inc.) software. One way analysis of variance was applied for each dependent variable (PT, PT/BW, concentric and eccentric hamstring quadriceps ratio, eccentric-hamstring to concentric-quadriceps and concentric-hamstring to eccentric-quadriceps ratio values) between different age groups. *In case of a variation between the results of the groups, Post-hoc Tukey tests have been used to determine the specific group that led to the variation.* Differences between dominant leg and non

dominant leg isokinetic strength values were examined by Paired t-tests. The significance level of $p < 0.05$ was set for all analyses.

RESULT

CONCENTRIC AND ECCENTRIC PEAK TORQUE VALUES: AGE EFFECTS

The concentric and eccentric PT values of four groups were analyzed through one way analysis of variance. According to the results, no significant difference has been observed on concentric and eccentric PT extension and flexion dominant and non dominant leg values between four age groups ($p > 0.05$). (These values are presented in Table 2, 3).

CONCENTRIC AND ECCENTRIC PEAK TORQUE VALUES: DOMINANT–NON-DOMINANT LEG

Dominant leg hamstring concentric PT values, concentric PT/BW and concentric H/Q strength ratio were greater than that of the non-dominant leg PT values ($p < 0.05$). No significant difference was found for eccentric PT values ($p > 0.05$) (Table 4).

TABLE 2: The values of concentric PT in four groups.

Groups	Concentric 60 degree/second (N-m)			
	PTED	PTEN	PTFD	PTFN
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
1	217.0 ± 28.6	218.3 ± 29.0	110.9 ± 15.5	105.3 ± 15.8
2	223.9 ± 31.4	225.3 ± 26.9	116.6 ± 21.6	111.5 ± 17.3
3	228.8 ± 31.7	231.6 ± 33.4	121.6 ± 20.9	117.0 ± 18.4
4	225.7 ± 30.6	228.3 ± 23.7	118.7 ± 21.2	113.5 ± 25.5

PTED: Peak torque for extension dominant, PTEN: Peak torque for extension non-dominant, PTFD: Peak torque for flexion dominant, PTFN: Peak torque for flexion non-dominant.

TABLE 3: The values of eccentric PT in four groups

Groups	Eccentric 60 degree/second (N-m)			
	PTED	PTEN	PTFD	PTFN
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
1	117.7 ± 29.4	167.5 ± 26.7	266 ± 62.8	264.8 ± 50.9
2	176.9 ± 38.8	165.4 ± 41.8	258.8 ± 83.3	253.8 ± 73.9
3	163.4 ± 37.3	175.8 ± 35.6	290.6 ± 75.0	293.7 ± 62.1
4	185.9 ± 31.2	186.1 ± 36.5	300.2 ± 49.2	277.6 ± 65.8

PTED: Peak torque for extension dominant, PTEN: Peak torque for extension non-dominant, PTFD: Peak torque for flexion dominant, PTFN: Peak torque for flexion non-dominant.

CONVENTIONAL H/Q (H_{CON}/Q_{CON} , H_{ECC}/Q_{ECC}) AND FUNCTIONAL (H_{CON}/Q_{ECC} , H_{ECC}/Q_{CON}) RATIO VALUES: AGE EFFECTS

Conventional H_{CON}/Q_{CON} ratio and functional H_{ECC}/Q_{CON} ratio of dominant leg values and conventional H_{CON}/Q_{CON} ratio and functional H_{ECC}/Q_{CON} ratio of non-dominant leg values were examined and no significant difference was found between different age groups.

When conventional H_{ECC}/Q_{ECC} ratio of dominant leg values were examined, a significant difference was found between groups ($F_{3/96}= 3.99$ $p< 0.05$). According to Post Hoc Tukey test a significant difference was observed only between Group 3 and group 2 for conventional H_{ECC}/Q_{ECC} ratios; values of group 3 (171 ± 29.6) were higher than those of group 2 values (145.5 ± 24.7 , Table 5).

Conventional H_{ECC}/Q_{ECC} ratio of non-dominant leg values were also examined, significant difference was observed between Groups ($F_{3/96}= 4.08$ $p< 0.05$). According to Post Hoc Tukey test a significant difference was observed between group 3 and group 2-4 values. Group 3 (177.3 ± 34.5) were higher than that of the group 2 values (151.1 ± 25.7) and group 4 values (150.2 ± 20.6 ; Table 6).

Functional H_{CON}/Q_{ECC} ratio of dominant leg values presented significant difference between Groups ($F_{3/96}= 3.45$ $P< 0.05$). According to Post Hoc Tukey test a significant difference was observed between group 3 and group 2 values. Group 3 values (76.8 ± 16.5) were higher than that of group 1 values (63 ± 9) (Table 5).

DISCUSSION

Strength testing is the most important variable for performance assessment in soccer. Isokinetic dynamometers can be used to provide safe and accurate information about muscle strength in soccer players and there is a low probability of injury during the test.^{5,18,19}

Several studies pointed out that as age increases, muscle strength gradually increases in athletes.^{1,8,18} However, the rate of strength and muscle gain appears to be greater from age 10-20, the years of rapid growth and development. Men, from 24-80 years, lose approximately 40% of total skeletal muscle mass. Total muscle strength peaks at the age of 24 years. From 24-50 years of age, 10% of the total muscle is lost. The decline in muscle mass may account, in part, for the decline in muscle strength seen with aging. But studies show that people of all ages can increase their muscle size and strength as a result of same strength training program.^{7,9} The result of our study indicates that no significant difference exists between peak torque values of four age groups. These results are in agreement with previous studies.⁸ This may result from the fact that soccer players do the same intensity and style of training. When we assess the relationship between age and H/Q strength ratios, the dominant H_{ECC}/Q_{ECC} and H_{CON}/Q_{ECC} and non-dominant leg H_{ECC}/Q_{ECC} strength ratios of groups 3 are higher compared to the other groups (Table 5, 6). This situation is an advantage for third group players. High

TABLE 4: The Comparison of concentric and eccentric isokinetic measurements between dominant and non-dominant leg.

	Concentric (60 degree/second)				Eccentric (60 degree/second)			
	Dominant	Non-dominant	t	p	Dominant	Non-dominant	t	p
	X ± SD	X ± SD			X ± SD	X ± SD		
PTE (N-m)	222.7 ± 30.2	224.4 ± 28.2	-0.9	0.36	176.5 ± 34.5	171.3 ± 35.7	1.8	0.73
PTF (N-m)	115.8 ± 19.7	110.6 ± 18.8	3.6	0.00*	273.3 ± 71.4	267.9 ± 64.3	1.0	0.28
PTE/BW (%)	316.3 ± 38.9	320.1 ± 35.3	-1.2	0.2	251.8 ± 45.2	244.6 ± 47.7	1.7	0.07
PTF/BW(%)	165.0 ± 25.3	157.8 ± 25.0	3.6	0.00*	389.7 ± 97.0	383.0 ± 88.9	0.9	0.34
HPT/QPT(%)	52.1 ± 6.3	49.5 ± 7.1	4.1	0.00*	154.1 ± 28.6	157.6 ± 27.7	-1.1	0.27

* $p<0.05$ PTE: Peak torque extension, PTF: Peak torque flexion,

PTE/BW: Peak torque extension/body weight, PTF/BW: Peak torque flexion/body weight

HPT/QPT: Hamstring peak torque/quadriceps peak torque.

TABLE 5: The values of dominant leg conventional (H_{CON}/Q_{CON} , H_{ECC}/Q_{ECC}) and functional (H_{CON}/Q_{ECC} , H_{ECC}/Q_{CON}) ratios in four groups percent \pm SD.

Groups	Dominant			
	H_{CON}/Q_{CON}	H_{ECC}/Q_{ECC}	H_{CON}/Q_{ECC}	H_{ECC}/Q_{CON}
1	51.2 \pm 5.3	150.2 \pm 30.5	63 \pm 9b	123.3 \pm 24.6
2	52.2 \pm 7.5	145.5 \pm 24.7a	68.4 \pm 18.1	116.1 \pm 35.1
3	53.3 \pm 6.5	171.1 \pm 29.6A	76.8 \pm 16.5B	126.2 \pm 23.9
4	52.6 \pm 5.6	162.9 \pm 23.5	64.8 \pm 12.9	134.5 \pm 22.8

H_{CON}/Q_{CON} : Concentric hamstring/quadriceps ratio, H_{ECC}/Q_{ECC} : Eccentric hamstring/quadriceps ratio, H_{CON}/Q_{ECC} : Concentric-hamstring to eccentric quadriceps ratios - H_{ECC}/Q_{CON} : Eccentric-hamstring to concentric-quadriceps ratio.

$p < 0.05 = A > a, B > b$

H/Q strength ratio in 21-23 age group means that muscle imbalance in knee muscles is in a good condition. This may reduce the risk of injury. These results are in agreement with previous studies which examined isokinetic H/Q strength ratio.²⁰

There may be muscular strength differences between dominant and non-dominant legs of footballers; due to the nature of the soccer game, knee muscle strength imbalances may be observed. Several researchers have reported symmetry between the dominant and non-dominant legs,⁶ whereas others suggest the existence of a significant asymmetry.²¹ According to Athanasias et al., there are different definitions of the word “dominance” by various authors, and this may be the cause of these contradictory results.¹⁰ Some researchers define it, as the leg preferred for kicking, others describe it as the stronger limb, and others do not specify how dominance was determined.¹³ In this study we pre-

TABLE 6: The values of non-dominant leg conventional (H_{CON}/Q_{CON} , H_{ECC}/Q_{ECC}) and functional (H_{CON}/Q_{ECC} , H_{ECC}/Q_{CON}) ratios in four groups.

Groups	Non-dominant			
	H_{CON}/Q_{CON}	H_{ECC}/Q_{ECC}	H_{CON}/Q_{ECC}	H_{ECC}/Q_{CON}
1	48.6 \pm 6.3	158.5 \pm 20.8	63.8 \pm 10.6	122.3 \pm 21.4
2	49.5 \pm 5.7	151.1 \pm 25.7c	71.8 \pm 23.3	113.8 \pm 32.2
3	50.7 \pm 6.2	177.3 \pm 34.5C	68.5 \pm 14.8	126.5 \pm 18.0
4	50.1 \pm 11.3	150.2 \pm 29.6c	61.1 \pm 8.7	122.3 \pm 27.5

H_{CON}/Q_{CON} : Concentric hamstring/quadriceps ratio, H_{ECC}/Q_{ECC} : eccentric hamstring/quadriceps ratio, H_{CON}/Q_{ECC} : Concentric-hamstring to eccentric-quadriceps ratios H_{ECC}/Q_{CON} : Eccentric-hamstring to concentric-quadriceps ratio $p < 0.05 = C > c$.

ferred dominant leg as the kicking leg. Our investigation showed that quadriceps PT values of the two legs were not significantly different. But hamstring concentric PT values, concentric PTF/BW and concentric H/Q strength ratio of the dominant leg were greater than non-dominant leg PT values. If the hamstring muscle strength value is high, naturally PTF/BW and H/Q strength ratio values are also high. This is an advantageous situation for soccer players. Because strong hamstring muscles increase the H/Q strength ratio, which in turn creates muscle imbalance between flexor and extensor muscles. The combination of these reduces the risk of injury. Also, it appears that soccer training programs a unique lateral dominance in soccer players.

The H_{CON}/Q_{CON} ratio serves as a screening tool for predisposition to injury. The isokinetic knee flexor/extensor balance is reported to play an important role in joint stabilization. According to Rosene et al, if the ratio is abnormal, this might be an injury factor.⁶ For example, during extension loads decreased antagonist hamstring co-activation may result in knee injury. Highly developed quadriceps muscle contributes to decreased antagonist hamstrings co-activation. H_{ECC}/Q_{CON} strength ratio reflects the role of the hamstrings in controlling knee extension and hip flexion. Conversely, H_{CON}/Q_{ECC} strength ratio reflects whether the quadriceps are controlling knee flexion and hip extension or not.^{6,10,11,14,17,18} Therefore attention must be given to proper muscle balance between agonist and antagonist muscle groups. But if the knee is injured, muscular imbalances between quadriceps and hamstring have to be rehabilitated. For this purpose, H_{CON}/Q_{CON} ratios of the opposite limb ratio should be used as reference point. But of course, the opposite limb has to be uninjured. In general; soccer training and rehabilitation focus on quadriceps strength because basic soccer movements require strong quadriceps. But actually, the purpose of the exercises should be obtaining an optimal H_{CON}/Q_{CON} ratio, because the strong quadriceps contraction causes the tibial translation. If the hamstring muscle is weak, problems about controlling the knee may arise this time.^{6,11}

PREDICTION OF HAMSTRING INJURY

A difference between agonist and antagonist muscle groups is disadvantageous to the weaker muscle group. Hypertrophy of the quadriceps at the expense of the hamstring may cause hamstring injuries. There is no agreement over the value of the normal H/Q strength ratio. By some authors, the normal H/Q strength ratio is considered to be 50% to 100% through the full range of knee motion.^{6,21-23} Other authors accept normal H/Q strength ratio value as %61, while some others accept it as 80%.^{11,12} The important thing about the H/Q strength ratio is the fact that the functional capacity of the hamstring to provide stability to the knee is increased as the ratio approaches towards 100%. This increased knee stability may reduce the possibility of an anterolateral subluxation of the tibia.^{6,22,23} However, surprisingly, some studies did not support a significant relationship between H_{CON}/Q_{CON} ratio and subsequent hamstring injury.^{11,21-23}

In the present study, dominant leg H_{CON}/Q_{CON} ratio value of only 10 over 102 players is found to be more than 60%, while that of 64 over 102 players is found to be more than 50%. Non-dominant leg H_{CON}/Q_{CON} ratio value of 5 players is calculated as more than 60%, while that of 51 players is calculated as more than 50%. In the light of all the information about H/Q strength ratio, in the long term, it might be thought that players whose H/Q

strength ratio is lower than 50-60% are more vulnerable to injury, especially injury of the hamstring muscles and knee.

CONCLUSION

According to the results of the present study relationship between isokinetic hamstring and quadriceps muscle strength and age does not appear in elite soccer players. Thus, one can infer that muscle strength may not be affected by age in soccer players. The findings of the study indicate that the H/Q strength ratio is influenced by age in players. The concentric muscle strength value of the dominant leg is expected to be higher than that of the non-dominant leg in all players. The result of the study is important in terms of highlighting the importance of preparing training programs in accordance with the physical fitness level of each soccer players. The determination of muscle profile of soccer players prevents knee injuries, especially hamstring muscle strain. Therefore testing and exercising programs have to be implemented in order to avoid these possible imbalances and injury rates.

In order to reduce knee injuries, further studies on the subject should be carried out. Future studies should cover more than 4 age groups and increased number of athletes in order to arrive at more definite results. This study provides a basis and can be adopted as a starting point for future studies.

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