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THE RELATIONSHIP BETWEEN ISOKINETIC STRENGTH OF KNEE FLEXORS-EXTENSORS AND JUMPING AND SPRINTING ABILITIES OF U19 ELITE A-LEAGUE PLAYERS- A PILOT STUDY

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Abstract

The purpose of this study was to investigate the relationship between knee flexor and extensor muscle strength and sprint and jump performance in U19 Elite youth A-league football players. The volunteers of this research were 26 male athletes having at least 5 years of experience and actively play football in the U19 Elite A-league of a professional football team (age: 19.31±0.73 years; body height: 174.48±6.48 cm; body weight: 68.25±5.96 kg; body fat: 22.00±1.43 percent). The extensor and flexor muscle strengths of the dominant and nondominant legs of the football players were measured. Knee flexion and extension peak torque values were measured in both knees at angular velocities of 60°·s-1 and 180°·s-1 via a Cybex Norm (CSMI, Stoughton, Massachusetts, the USA) isokinetic dynamometer. In addition, the sprint and jump performances of these football players were respectively measured with 30-m sprint test and the Countermovement Jump test (CMJ). It was determined that there was no correlation between 30-m sprint and CMJ performances and isokinetic knee flexion, extension, peak torque strength, and Hamstring-to-Quadriceps Ratio (H/Q 60°-180°) ($p>0.05$). As a result, among the factors affecting the 30-m sprint time and CMJ height in U19 Elite A-league football players, the knee flexor-extensor values at 60°-180° angular velocity and the H/Q ratio were absent; however, many other factors such as the maximal strength and cross-sectional area of certain muscles were thought be effective factors. Furthermore, two different isokinetic angular velocity

assessments were performed in our study. It is suggested that to create a general profile, studies on isokinetic strength at various angular velocities should be conducted in order to correlate 30-m sprint performance with CMJ performance.

Keywords: Elite football league, isokinetic strength, bio motor abilities

U19 ELİT A LİGİ OYUNCULARINDA DİZ FLEKSÖR-EKSTANSÖR İZOKİNETİK KUVVETİ ILE SPRİNT VE SIÇRAMA PERFORMANSI ARASINDAKİ İLİŞKİ; PİLOT BİR ÇALIŞMA

ÖZET

Bu çalışmanın amacı; U19 Elit A-ligi genç futbolcularda diz fleksör ve ekstansör kas kuvvetinin, sprint ve sıçrama performansıyla ilişkilerinin incelenmesidir. Bu araştırmaya profesyonel bir futbol takımının U19 Elit A-liginde en az 5 yıllık sporcu geçmişi olan ve aktif futbol oynayan; yaş ortalamaları 19.31±0.73 yıl, boy uzunluğu ortalamaları 174.48±6.48 cm, vücut ağırlığı ortalamaları 68.25±5.96 kg, vücut yağ oranı ortalamaları 22.00±1.43 olan 26 erkek futbolcu gönüllü olarak katılmıştır. Futbolcuların dominant ve nondominant bacağın ekstensör ve fleksör kas kuvvetleri ölçülmüştür. Diz fleksiyon ve ekstansiyon zirve tork kuvveti Cybex Norm (CSMI, Stoughton, Massachusetts, ABD) izokinetik dinamometre ile 60°·s-1, 180°·s-1 'lik açısal hızlarda her iki dizde ölçülmüştür. Futbolcuların sprint ve sıçrama performansları ise sırasıyla 30 m sprint testi ve counter movement testi (CMJ) ile değerlendirilmiştir. Elde edilen verilere göre; 30m sprint ve CMJ ile izokinetik diz fleksiyon, ekstansiyon, zirve tork kuvveti ve Hamstring-to-Quadriceps Ratio (H/Q 60°-180°) arasında korelasyon olmadığı tespit edilmiştir ($p>0.05$). Sonuç olarak; U19 Elit A- ligi futbol oyuncuları için 30 m sprint süresi ve CMJ yüksekliğine etki eden faktörler arasında 60°-180° açısal hızlardaki diz fleksör-ekstansör kuvvet değerleri ve H/Q oranının olmadığı bunun yanında maksimal kuvvet, ilgili kasların enine kesit alanı gibi başka birçok faktörün etkili olabileceği düşünülmektedir. Ek olarak, çalışmamızda iki farklı izokinetik açısal hız değerlendirmesi yapılmıştır. Genel bir profil oluşturabilmek açısından 30 m sprint ve CMJ performansıyla ilişkilendirebilmek için daha fazla açısal hızda izokinetik çalışmalar yapılmalıdır.

Anahtar kelimeler: Elit futbol ligi, izokinetik güç, biomotor yetiler

INTRODUCTION

Football is an intermittent sport in which physical, technical, and tactical parameters contribute to team performance (Diker et al., 2022). Performance evaluation and consequently success in football is determined by tactical, biomechanical, and physiological parameters (Ön and Diker, 2022). It is expected football players have improved speed, agility, balance, muscle strength and maximum aerobic-anaerobic capacity (Buzdağlı et al., 2022). The main purpose of days, weeks, months and sometimes years of training before the match in football is to improve and maximize the performance of athletes. Moreover, it is also aimed to maintain this and to show the maximum performance during the competition (Söyler and Kayantaş, 2020).

Muscle strength comes first among the factors affecting the physical performance of football players and, thus, their success (Brooks et al., 2013). Football is a sport that requires great muscle strength and coordination of working muscles. Great muscle strength is an important parameter for great performance. In many studies, the absolute necessity of muscle strength for performance, endurance and success in sports has been reported.

Athletes need to have the necessary muscle strength, joint mobility, and good coordination in order to increase or maintain their performance (Aksu, 2015).

Developing optimal muscle strength, especially lower extremity muscle strength, in football is especially important in certain movements such as sprinting, jumping, changing direction, passing, and shooting, and it can be assessed objectively with isokinetic dynamometers. In addition, it has been reported that the muscle groups around the knee highly activated while kicking, jumping, running, and changing direction (Mallileo et al., 2003). In order to maximize the physical performance of football players, isokinetic dynamometers make important contributions when analysing parameters based on muscle strength in detail and when determining the points to be emphasized in football training (Cometti et al., 2001).

Further research on isokinetic dynamometers is required to determine the hamstring/quadriceps (H/Q) strength ratio in order to make correct decisions about muscle balance and knee joint stabilization. The commonly used 'conventional' hamstring to quadriceps ratio (H/Q ratio) represents the ratio of the concentric peak torque during knee flexion to the concentric peak torque during knee extension (Dvir, 1989). However, the relationship between H/Q ratio and sportive performance (i.e., sprint and jump) has not been investigated sufficiently (Diker et al., 2022). This ratio is also accepted as an appropriate tool to determine footballers' tendency to get injuries (Miller et al., 2006). The significance of extensor-flexor muscle strength balance and H/Q ratio is also the reason why they are used in post-injury rehabilitation (Alangari and Al-Hazzaa, 2004).

Hamstring (H) and Quadriceps (Q) muscle groups are of primary significance in football. Many epidemiological studies have shown the relationship between weak hamstring muscle strength and acute hamstring injuries in male athletes. Quadriceps femoris, which is the single extensor muscle of the knee joint, is the most important dynamic structure affecting the knee joint. This muscle group shows its effect on the stabilization of the knee joint through the patella and patellar tendon (Karsan et al., 1999). While the quadriceps muscle group plays an important role while jumping, balancing, and kicking the ball, the hamstring muscle group maintains the stability of the knee while running and changing direction (Masuda et al., 2005).

Furthermore, speed and anaerobic power are the main factors that increase the success of a football player. They need to be fast and agile while running, attacking, and defending during the game (Vaczi et al., 2013). In a football game, muscles need to create greater torque during acceleration and deceleration in linear sprint movements and during agility movements and change of direction (Maly et al., 2015: 62). High eccentric knee flexor strength is essential to increase athletic performance and endurance of the hamstring muscles (Al Attar et al., 2017: 909). Agility in football is thought to be closely related to explosive power, which is the ability of a muscle or muscle group to develop maximum force in the shortest time possible (Thomas et al., 2009: 333).

Most physical activities in football and sports branches consist of locomotor movements such as sprinting, running, jumping, and walking. These movements require the use of the main-joint flexor and extensor muscles

of the hip, knee, and ankle (Rahnama et al., 2006). The fact that players with high sprinting velocity values have an important and valuable role in movements such as stopping the opponent, possessing the ball, protecting the ball, and scoring goals in football matches is known (Newman et al., 2004). It is also stated that many situations that affect the result in football occur during or after reaching high sprinting velocity (Pauole et al., 2000). The relationship between strength and speed plays an important role in achieving maximum efficiency in sports. In addition, the desired speed cannot be reached with underdeveloped muscle strength (Yeefun et al., 2002).

Jumping, which means an organism pushing the supporting surface and leaving the ground in the vertical or horizontal axis and staying in the air for a short time, is the most important training goal to be achieved and one of the important conditions of high sportive performance in football, as in most sports (Gioftsidou et al., 2006). Jumping strength increases combined far and high jump of athletes as they apply technical elements during game. It enables high difficulty technical movements to be performed well and effectively by extending flight-time of the athlete when jumping far and high. In order to jump higher, which means the ability to rise in the air in a quick, explosive, and dynamic way and to leave the ground quickly, strength is of great importance. In addition, factors affecting an effective vertical jump are physiological structure, correct technique, time, and training (Newman et al., 2004).

Due to the technical and tactical characteristics of football, players playing in different positions have to control the ball coming from the air during a match without the pressure of the opponent. In order to do it and give an advantage to the opponent, footballers must display the ability to vertically jump well (Binet et al., 2005). Characteristics of jump and speed, which have an effect on both strength and force, are significant performance factors in football.

Considering all this information, two main objectives were set for this study. The primary aim of the study was to determine the peak torque values produced by the flexor (hamstring) and extensor (quadriceps) muscles during knee flexion and extension of the dominant and nondominant leg in football players playing in the Elite A-league. The second aim is to investigate the relationship between the peak torque values and H/Q ratios produced by the hamstring and quadriceps muscles during knee flexion and extension with vertical jump and 30-m sprint tests.

MATERIAL AND METHOD

Participants

26 male athletes playing in the U19 Elite A-league in the youth category of a professional football team volunteered for the study (age: 19.31±0.73 years; body height: 174.48±6.48 cm; body weight: 68.25±5.96 kg; body fat: 22.00±1.43 percent). The athletes were informed about the purpose, procedure, possible contributions and possible risks or discomforts of the research, and the informed consent form was signed by

the families of the participants. Ethical approval for this study was obtained from Bilecik Şeyh Edebali University Ethics Evaluation Committee, and the study was conducted following the World Medical Association Declaration of Helsinki (Approval code: 2022/02- E-10333602-050.01.04-88531).

Method

The research was conducted with academy league athletes playing football in the U19 Elite A-league of a professional team (Ankara) of the Turkish Football Federation Super League. Measurements for the research were taken in the second preparatory season (on the third week) of 2022-2023 U19 Elite-A league football season. To collect data, four tests in two stages were conducted. In the first stage, on the first day, height and body composition analysis measurements were made in the indoor gym of the club (at 10:00 am), and jump and speed tests were conducted in the training field of the professional team (on natural grass/at 16:00 pm). In the second stage, on the second day, isokinetic strength measurements were taken via the Cybex Norm (CSMI, Stoughton, Massachusetts, USA) isokinetic dynamometer located in performance laboratory of the professional team (A team) (at 10:00 am). The players were informed about the purpose and procedure of the tests, and they were asked to apply maximal strength during the measurements. Extremity dominance (dominant leg) which is used when hitting the ball was set as the preferred leg.

The order of all measurements, which consisted of the extensor and flexor muscle strength, vertical jump, and 30-m speed parameters of the dominant and non-dominant legs of the football players, was random for each athlete. All athletes were tested at the same time of day to eliminate the circadian rhythm effect. They were asked not to do any training the day before the tests and to stop eating at least 2 hours before the tests were performed.

Table 1: Timeline of the Measurements

Days	Measurement
Sunday	Rest Day
Monday	(at 10:00 am) Height Measurement/Body Composition Analyses
	(at 16:00 pm) Countermovement Jump (CMJ) – Sprint 30-meter tests
Tuesday	(at 10:00 am) Isokinetic Leg Strength test
Wednesday	Rest Day
Thursday	Football Training
Friday	Football Training

Inclusion criteria for the study were determined as follows:

- Training at least 5 days a week in the infrastructure of a professional football club,
- Being an active athlete for at least 5 years,

- Being a licensed athlete of the club,
- Having no history of musculoskeletal, neurological, or cardiorespiratory injury in the last six months,
- Having no muscle or ligament injury to the lower extremities limiting normal activity for more than 48 hours in the two years preceding the test.

The warnings to athletes in the study were as follows:

- Not consuming performance-enhancing substances (creatine, ribose, glutamine, etc.),
- Limiting the caffeine intake to a cup before the tests,
- Having a rested metabolism before the tests and avoiding strenuous work,
- No physical activity 24 hours before the tests.

Anthropometric and Body Composition Measurements

Anthropometric measurements which are body height, body weight, body fat percentage and body mass index were taken in the study. The body composition was measured via an Inbody fat scale (Inbody270). This scale indirectly measures the body composition with a safe electrical signal transmitted through the body via electrodes located in the standalone unit. The Inbody Scale allows athletes to check their body weight, health, and form along with all relevant parameters in the athletics mode (Gardasevic et al., 2019).

Body Height Measurement

The height of the participants was measured via a stadiometer [Seca model 213, Germany (accuracy of ± 5 mm)]. Participants stood upright with their feet bare and placed together, and they touched their lower back, head, shoulder blades, buttocks, and heel to the stadiometer. After achieving the correct position, the measurements were taken vertically with the help of a rod touching at the top of the head (Nobari et al., 2021).

Body Weight, Body Fat Percentage and Body Mass Index

Having their heights measured and recorded, the participants continued with the measurement of the body composition. Body weight (kg) and body fat (%), BMI (kg/m^2) measurements of the participants were performed using the bioelectrical impedance analysis (BIA) method (Inbody 270 Body Composition Analyzer, model Plus 270) which is a method based on the electrical permeability difference of lean tissue mass and fat (Miller et al., 2016). Body composition measurements of the football players were taken between 8:30 and 12:00 in the morning after having used the restroom, and the participants were asked not to have anything to eat or drink after dinner the day before the tests. Before the measurements, they were also asked to remove any accessories and wear light clothes. During the measurements, they were requested to hold the hand electrodes and stand in a vertical position pressing on the aluminium soles of the analysis tool with bare feet. The data were recorded with the help of a computer connected to the body composition analyser.

Team Performance Measurement

Countermovement Jump (CMJ)

The CMJ is used to assess anaerobic power in football (Castagna and Castellini, 2013) and is accepted to be valid and reliable test while assessing lower extremity power (Markovic et al., 2004). It was tested on a flighttime-based jump mat (Fusion Sport Smart Jump mat, Fusion Sport, Australia). Before the test, the athletes were instructed to stand at the centre of the mat, then they were asked to bend their knees and lower their hips to the depth they chose to (McLellan et al., 2011). Next, without stopping, they were instructed to jump for a maximal height with their knees fully extended. During the test, the participants were free to swing their arms encouraging force generation. They conducted the test twice with one-minute of rest in between. The highest vertical jump value was taken into account in data analysis (Markovic et al., 2004).

Sprint Testing (30-meter)

Maximal sprinting speed of the participants was tested with a sprint of 30 meters. For this, four infra-red timing gates (Fusion Sport Smart Speed, Fusion Sport, Australia) were placed at the start (0 meters) and end of 30 meters to record the times of the participants in milliseconds. The athletes performed the test twice with a five-minute rest in between. Before the test, each participant standing in a static position put their dominant foot on a line 15 cm behind the first gate. The time started to be recorded when the participant passed the first timing gate starting from this position (Wisløff et al., 2004). The fastest time they obtained was taken into account in data analysis.

Isokinetic Strength Test

After participants performed a supervised (by the researcher) warm-up including six-minute cycling on a stationary cycle ergometer at a self-regulated low to moderate intensity and five-minute stretching aiming the main muscle groups targeted in the study, they performed the tests.

Knee flexor and extensor muscle strengths of the football players participating in the study were measured using Cybex Norm (CSMI, Stoughton, Massachusetts, the USA) brand isokinetic dynamometer at angular velocities of 60 and 180 deg/sec. The test was performed with the athletes seated and secured to the seat with tapes from their chest and mid-thigh, and the shoulders were stabilized with shoulder pads in the ventral-dorsal and cranial-caudal directions. The axis of rotation of the dynamometer was aligned with the axis of rotation of the knee (lateral femoral epicondyle), and the arm of the dynamometer was fixed to the distal part of the tibia, and the lower edge of the shin pad was placed 2.5 cm above the medial apex malleolus. In addition, by holding the arms of the seat on both sides, the movement of the arms during the test was prevented, so the participants' arms were supported by the seat. Concentric-concentric isokinetic knee strength test consisting of 10 repetitions at an angular velocity of 60 deg/sec and 15 repetitions at an angular

velocity of 180 deg/sec was applied, and 3 trial rounds were performed for each test before the actual test was conducted. The same test was performed for both legs of the football players. Between the two angular velocity tests, the participants were given a three-minute rest. The football players were supported verbally with encouraging expressions in order to for them to exhibit higher performance during the tests (Clemente et al., 2019).

The H/Q ratio was calculated using the following equation:

H/Q ratio = [(Fl + Fr)/ (El + Er)] · 100%

(Fl + Fr) and (El + Er) are the sum of the left and right lower extremity peak torque values of the knee joint flexors and extensors, respectively (Struzik, 2019).

Statistical analysis

SPSS 23 (SPSS Inc., Chicago, IL, the USA) software was used for the statistical analysis of the data obtained in the study. Variance homogeneity of the data was done using Levene Test, and normality of the data was assessed using Shapiro-Wilk Test. Pearson Correlation analysis was used in the analysis of all parameters. Significance was set as $p<0.05$.

Results

Age, height, body weight, body mass index (%), CMJ, 30-m sprint, H/Q 60°/s and H/Q 180°/s values of the football players participating in the study are presented in the table below (Table 2).

Table 2: The Physical Characteristics of the Football Players (n=26)

Variables	$\bar{x}$ ± sd
Age (year)	19.31±0.73
Body Height (cm)	174.48±6.48
Body Weight (kg)	68.25±5.96
Body Mass Index (kg/m^2)	22.00±1.43
CMJ (cm)	37.20±4.57
30-m Sprint (sec)	4.04±0.25
H/Q 60°/s	61.05±8.98
H/Q 180°/s	68.49±7.42

$\bar{x}$: mean; sd; standard deviation

Table 3: Peak isokinetic concentric knee flexion and extension torques

Variables	Isokinetic Test	$\bar{x}$ ± sd
Right Leg	60°·s-1 Flexion	129.35±27.22
	60°·s-1 Extension	211.46±31.42
	180°·s-1 Flexion	99.15±16.27
	180°·s-1 Extension	142.65±18.09
Left Leg	60°·s-1 Flexion	129.00±23.08
	60°·s-1 Extension	212.61±28.58
	180°·s-1 Flexion	97.23±17.88
	180°·s-1 Extension	144.38±19.75

$\bar{x}$: mean; sd; standard deviation

Peak isokinetic concentric knee flexion and extension torque of the participants are given in Table 3.

Table 4: Correlations between peak isokinetic concentric knee flexion and extension peak torque and the 30-m sprint and Countermovement Jump tests

		Right Leg		Left Leg	
Variables		r	p	r	p
30-m Sprint	**60°·s-1 Flexion**	0.19	0.35	0.14	0.49
	60°·s-1 Extension	0.98	0.63	0.15	0.47
	180°·s-1 Flexion	0.03	0.87	0.20	0.32
	180°·s-1 Extension	0.12	0.57	0.18	0.37
Countermovement Jump	**60°·s-1 Flexion**	0.23	0.24	0.07	0.73
	60°·s-1 Extension	0.08	0.69	0.06	0.75
	180°·s-1 Flexion	0.23	0.26	0.08	0.68
	180°·s-1 Extension	0.17	0.42	0.05	0.78

r: correlation coefficient; p<0.05

30-meter sprint and CMJ (sec) test results are presented in the Table 4. In the table, correlations between peak isokinetic concentric knee flexion and extension peak torque tests, and the 30-meter sprint and CMJ (sec) tests are given. It can be seen that there is no statistical correlation between the isokinetic concentric knee flexion and extension torque and either the 30-meter sprint or Countermovement Jump tests (p>0.05).

Table 5: Correlations between H/Q (60°-180°) ratios and the 30-m Sprint and CMJ tests

	H/Q 60°		H/Q 180°	
Variables	**r**	**p**	**r**	**p**
30-m Sprint	0.104	0.61	-0.006	0.98
CMJ	0.182	0.37	0.104	0.61

r: correlation coefficient; p<0.05

When the Table 5 is examined, it is seen that no correlation between H/Q (60°-180°) ratios and the 30-m sprint and CMJ tests was found.

DISCUSSION

The aim of this study was to investigate the relationship between the peak torque values and H/Q ratios produced by the hamstring and quadriceps muscles during knee flexion and extension of the dominant and non-dominant leg with vertical jump and 30-m sprint test performances of football players in Elite Academy League.

The findings (Table 4) showed no correlation between peak isokinetic knee flexion and extension torque and sprint and vertical jump performances when evaluated at various velocities ($p>0.05$). Another finding of the study (Table 5) is that there is no statistically significant relationship between H/Q (60°-180°) ratios and vertical jump and sprint tests results ($p>0.05$).

The number of studies investigating the relationships between H/Q ratios and jump and sprint performances in football is only few (Struzik, 2019; Diker, 2022). In a study with similar results to ours, no correlation was found between vertical jump and H/Q (60° and 180°) ratios at different angular velocities of young football players (Diker, 2022). In the same study, although no correlation was found between 30-m sprint performance and H/Q ratio at an angular velocity of 180°, it was reported that H/Q ratio at angular velocity of 60° correlated with 30-m sprint performance ($r=0.47$). Additionally, in another study, there seen a correlation between female soccer players' vertical jump performance and H/Q ratio at angular velocity of 60° ($r=0.41$) (Struzik, 2019).

When the literature is reviewed, at the moment of a vertical jump before going into the push off phase, an eccentric downward movement is performed to provide range of motion to the quadriceps muscles which will concentrically contract, so the jump is performed with a vertical counter movement (Arvas et al., 2006). When the studies are examined, it is seen that there are various results on this matter. For instance, while Apaydın (2020) found that lower extremity strength variables did not have a significant effect on vertical jump height in female football players, Başpınar (2009) observed the effect of quadriceps and hamstring strength measured at angular velocities of 60 and 180 deg/sec on vertical jump values in young male football players. Furthermore, in their study Malliou et al. (2003) found a high level of correlation between isokinetic knee extensor strength and vertical jump value at an angular velocity of 60 deg/sec and 180 deg/sec in 18 professional football players during the preparation period. In the study of Salaba and Hrysomallıs (2001) with Austrian football players, knee flexion and extension were measured at angular velocities of 60, 180, and 360 deg/sec.

On the other hand, in their study González-Ravé et al. (2014) found no correlation between isokinetic knee flexion and extension peak torques and vertical jumping performance in elite handball players explaining that vertical jumping is a closed chain and multi-joint task involving a stretch-shortening cycle type of motion, and neuro-muscular coordination during the jump affects the skill significantly. However, they also pointed out that isokinetic testing is an open kinetic chain test at a constant angular velocity managed by the tool used.

In this study, no significant relationship was found between muscle strength and vertical jump values in isokinetic measurements. It is well-known that quadriceps muscle strength affects the jump performance and also reduces injuries in football players when its primary significance in jumping performance is investigated (Tsiokanos et al., 2002). The reason why no significant correlation was found in our study is thought to be due to the isokinetic test's movement profile being based on sitting in an isolated environment, the sprint performance depending on running, and the vertical jump performance depending on functional strength, so each exhibit different movement profiles.

The hamstring muscle group is one of the most important muscles involved in running (Karsan et al., 1999). Sprint performance is highly dependent on muscle strength, and it is known that this performance can be improved by increasing muscle strength (Schmidt, 1991; Marullo, 2002). In the study, there was no correlation between the absolute flexor and extensor strength of the dominant and nondominant legs and 30-m speed, and between the relative extensor strength of the dominant leg at an angular velocity of 60 deg/sec and 30-m speed.

Reviewing the literature, it is seen that Cometti et al. (2001) also found no correlation between isokinetic strength (knee flexion and extension at 120°·s-1 and 300°·s-1) and anaerobic performance (10-m and 30-m sprinting) in elite, sub-elite, and in amateur French football players. Özçakar et al. (2003) reported a negative weak correlation between quadriceps muscle strength and speed at angular velocity of 60 deg/sec in 29 elite football players aged from 18 to 31 years.

In addition, Cronin and Hansen (2005) stated that there was no correlation between strength and knee extension and flexion strength and speed, whereas Alemdaroğlu (2012) found out that sprint performance at angular velocities of 60 and 180 de/sec and muscle strength related to it were not found to be correlating in their study. Newman et al. (2004) also found no correlation between isokinetic knee flexion and extension peak torques and anaerobic performance in sprint tests. While in isokinetic tests, the phosphate system (ATP-CP) is the dominant energy system, the glycolytic energy system (lactic anaerobic system) accompanying the ATP-CP system is dominant in testing sprint performance. As a result, the sprint characteristics were found to be largely correlated with the hamstring and quadriceps ratio. Therefore, the development of muscle groups of players at this age group will result in improved sprint performance.

To sum up, among the factors affecting the 30-m sprint speed and vertical jump height of U19 Elite A-League football players, there were no knee flexor-extensor force values at 60°-180° angular velocities and H/Q ratio. It is thought that many other factors such as maximal strength and cross-section of the relevant muscles may be effective ones.

On the other hand, although the tests applied to the players of this age group was scheduled in a professional way, the fact that there is no significant correlation in the 30-m sprint performance of the players in this age

group could be due to a reluctance to perform the sprint test right after the vertical jump and isokinetic strength tests and due to the poor performance of these players because of fatigue and the lack of attention and concentration.

Suggestions for Further Research

This study was conducted to investigate the effect of isokinetic knee muscle strength on vertical jump performance and speed in football, and here are several suggestions for further research on this topic:

- Test protocols can be arranged as periods spread out at the beginning of the season, in the middle of the season and at the end of the season, depending on the performance monitoring with this age group,
- Depending on the risk of injury, individual strength programs for muscle strength exercises can be applied to the football player throughout the year.
- It is known from research that the lower the age of the athlete, the more desired is the H/Q ratio strength of these players. In order to keep this rate at the desired level, it is recommended to perform the right training plan, program and methods.
- Such tests can be done with trainers present, and it can be ensured that the annual plan and periodization are adjusted according to isokinetic measurement values.
- It is recommended to divide the test planning and protocols into different days in order to minimize the level of boredom in this age group, which is considered as the most important factor.

Declarations

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Ethics Text

In this article, during the research process, 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. Ethical approval for this study was obtained from Bilecik Şeyh Edebali University Ethics Evaluation Committee, and the study was conducted following the World Medical Association Declaration of Helsinki (Approval code: 2022/02- E-10333602-050.01.04-88531).

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Genişletilmiş Özet

Çalışmanın Amacı: Bu çalışmanın amacı; U19 Elit A-ligi genç futbolcularda diz fleksör ve ekstansör kas kuvvetinin, sprint ve sıçrama performansıyla ilişkilerinin incelenmesidir.

Literatur Araştırması: Futbolcuların fiziksel performanslarını ve buna bağlı olarak başarılarını etkileyen faktörlerin başında kas kuvveti gelmektedir (Brooks vd., 2013). Futbolcuların fiziksel performanslarını en üst düzeye çıkarabilmek için kas kuvvetine dayalı parametrelerin ayrıntılı bir şekilde analiz edilebilmeleri ve futbol antrenmanlarında ağırlık verilecek noktaların belirlenmesinde izokinetik dinamometrelerin önemli katkıları olmaktadır (Cometti vd., 2001). İzokinetik dinamometrelere yönelik kas dengesi ve diz ekleminde stabilizasyon hakkında doğru kararlar verebilmek için hamstring/quadriceps (H/Q) kuvvet oranlarını saptamaya yönelik araştırmaları gerektirmektedir. Yaygın olarak kullanılan "geleneksel" hamstring / kuadriseps oranı (H/Q oranı), diz fleksiyonu sırasındaki konsantrik tepe torkunun diz ekstansiyonu sırasındaki konsantrik tepe torkuna oranını temsil eder (Dvir, 1989). Fakat, H/Q oranı ile sportif performans (örn. sprint ve sıçrama) arasındaki ilişkiler yeterince araştırılmamıştır (Diker vd. 2022). Futbol sporunun teknik ve taktik özelliği gereği değişik mevkilerde oynayan futbol oyuncuları, bir müsabaka boyunca gerek rakip baskısı gerekse olmaksızın havadan gelen toplarla mücadele etmek durumundadır. Havadan gelen topa sahip olmak ve rakibe avantaj sağlayabilmek için

futbolcuların iyi bir dikey sıçrama özelliğine sahip olmaları gerekir (Binet ve diğ., 2005). Hem kuvvet hem de kuvvete etkisi olan sıçrama ve sürat özellikleri futbolda performansın önemli öğelerindendir. Bu çalışmada iki temel amaç belirlenmiştir. Çalışmanın birinci amacı, Elit A- liginde oynayan futbolcularda dominant ve nondominant bacağın dizin fleksiyonu ve ekstensiyonu sırasında fleksör (hamstring) ve ekstensör (quadriceps) kaslarının ürettiği zirve torklarını belirlemektir. İkinci amaç ise, dizin fleksiyonu ve ekstensiyonu sırasında hamstring ve quadriceps kaslarının ürettiği zirve tork değerleri ve H/Q oranlarının, dikey sıçrama ve 30 m sürat koşu performansıyla ilişkisisin incelenmesidir.

Yöntem: Bu araştırmaya profesyonel bir futbol takımının alt yaş kategorisi U19 Elit A- liginde oynayan; yaş ortalamaları 19.31±0.73 yıl, boy uzunluğu ortalaması 174.48±6.48 cm, vücut ağırlığı ortalamaları 68.25±5.96 kg, vücut yağ oranı ortalamaları 22.00±1.43% olan 26 erkek futbolcu gönüllü olarak katılmıştır. Futbolculara, araştırmanın amacı, yöntemi, olası katkıları ve oluşabilecek olası risk veya rahatsızlıkları içeren bilgiler verilmiş, bilgilendirilmiş gönüllü onam formu katılımcıların aileleri tarafından imzalanmıştır.

Sonuç ve Değerlendirme: Sonuç olarak U19 Elit A- ligi futbol oyuncuları için 30 m sprint süresi ve dikey sıçrama yüksekliğine etki eden faktörler arasında 60°-180° açısal hızlardaki diz fleksör-ekstansör kuvvet değerleri ve H/Q oranı olmadığı bunun yanında maksimal kuvvet, ilgili kasların enine kesit alanı gibi başka birçok faktörün etkili olabileceği düşünülmektedir. Diğer taraftan bu yaş grubu oyuncularına uygulanan testlerin periyodlaması ne kadar profesyonel bir şemada yapılsa da 30 m sprint performansı arasında anlamlı korelasyon olmamasını bu yaş grubundaki futbolcuların dikey sıçrama ve izokinetik kuvvet testlerinin bitiş aşamasından sonra yapılmasına bağlı bir isteksizlik, dikkat ve konsatrasyon eksikliğine bağlı yorgunluğu vermiş olduğu düşük performansa da bağlayabiliriz.