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The relationship between isokinetic strength and anaerobic performance in elite youth football players

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Abstract

The purpose of our study was to examine the relationship between isokinetic strength and anaerobic performance in elite youth male football player. Nineteen voluntary athletes were included in the study. All athletes trained in the same football academy. All youth male athletes performed an anthropometric test, anaerobic power test and an isokinetic strength test at 60º/sec angular speed both limbs. Peak torque values were directly obtained from isokinetic dynamometer and Relative Peak Torque values were calculated by dividing peak torque values by body weight of the athlete. The relationships between anaerobic power and isokinetic strength outputs were determined using an analysis of pearson correlation coefficient. The data obtained from the research were shown as mean ± SDs. Peak torque of extensor and flexor muscles in both extremities at 60º/sec. and wingate anaerobic peak power strongly related to each other ($p<0.01$) and relative peak torque of right knee extensor muscles and anaerobic relative peak power were moderately related to each other ($p<0.05$); However, the relative peak torque values of left leg extensor muscles and anaerobic relative peak power values have no significant relation ($p>0.05$). Besides, there was no relationship between the relative peak torques of both leg flexor muscles and anaerobic relative peak power values ($p>0.05$). Importantly, isokinetic parameters and anaerobic power parameters were highly related in youth elite football players.

Keywords: Soccer, anaerobic, isokinetic, performance, athlete, power

Elit genç futbolcularda izokinetik kuvvet ve anaerobik performans arasındaki ilişki

Özet

Çalışmamızın amacı, elit genç erkek futbolcularda izokinetik kuvvet ile anaerobik performans arasındaki ilişkinin incelenmesidir. Çalışmaya aynı futbol akademisinde düzenli antrenman yapan 19 gönüllü sporcu dahil edilmiştir. Tüm genç erkek sporculara antropometrik testler, anaerobik güç testi ve her iki ekstremitede 60º/sn açısal hızda izokinetik kuvvet testleri yapılmıştır. Tüm testler öncesinde gerekli olan kalibrasyon ve ısınma prosedürleri uygulanmıştır. Zirve tork değerleri doğrudan izokinetik dinamometreden elde edilmiş ve Rölatif Zirve Tork değerleri, zirve tork değerlerinin sporcunun vücut ağırlığına bölünmesiyle hesaplanmıştır. Anaerobik güç ve izokinetik güç çıktıları arasındaki ilişkiler, pearson korelasyon analizi kullanılarak belirlenmiştir. Araştırmadan elde edilen veriler ortalama ve standart sapma olarak gösterilmiştir. Her iki ekstremitede 60º açısal hızda ekstansör ve fleksör kasların zirve torku ile Wingate anaerobik zirve gücü arasında istatistiksel olarak güçlü bir ilişki olduğu belirlenmiştir ($p<0,01$) ve sağ diz ekstansör kaslarının rölatif zirve torku ile anaerobik rölatif zirve gücü birbiriyle orta derecede ilişkili olduğu belirlenmiştir ($p<0,05$). Ancak sol bacak ekstansör kaslarının rölatif zirve tork değerleri ile anaerobik rölatif zirve güç değerleri arasında anlamlı bir ilişki bulunamamıştır ($p>0,05$). Ayrıca her iki bacak fleksör kasının rölatif zirve torkları ile anaerobik rölatif zirve güç değerleri arasında da ilişki bulunamamıştır ($p>0,05$).

Anahtar Kelimeler: *Futbol, anaerobik, izokinetik, performans, güç, sporcu*

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Genişletilmiş Türkçe Özet makalenin sonunda yer almaktadır.

INTRODUCTION

Soccer is among the most common team sports and its popularity is growing day by day all around the world. The reason for its popularity is that people of all ages can play it at a beginner or elite level (Stølen et al., 2005). The popularity of football also has allowed it to take place in a large number of scientific studies. There are scientific studies on physiological (Slimani et al., 2019), psychological (Scharfen & Memmert, 2019), biomechanical (Fílter et al., 2022) and technological (Modric et al., 2019) in football. Increasing the performance is possible by increasing the physiological and psychological skills to the highest level. Hence, Performance analyzes are important in evaluating the success of athletes (Carling et al., 2005; Hughes et al., 2019).

Soccer is a game that requires movement of varying intensity and intermittent during 90 minutes (Yanci et al., 2016). Aerobic and anaerobic energy mechanisms are required to provide the energy needs of muscles throughout the soccer game (Meckel et al., 2009). Although aerobic metabolism is intensely demonstrated in energy use in the soccer game, athletes perform short-term actions (e.g., sprint, jump, kick, and tackle) that are supplied by the anaerobic energy system in the soccer game. It is considered that these movements require explosive power and strength of lower limbs as well as anaerobic fitness. This is often crucial for the match outcome and performance (Can et al., 2019; Stølen et al., 2005; Wragg et al., 2000). Thus, muscle strength measurements are often included in the assessment of anaerobic capacity in players (Yanci et al., 2016).

Strength at all levels is required to perform intermittent movements at high capacity. There are studies showing that strength is associated with sprint performance (Barrera et al., 2023), 100 m performance (Smirniotou et al., 2008), vertical jumps (Śliwowski et al., 2018; Uslu et al., 2021), explosive power and anaerobic performance (Atabek & Sönmez, 2009; Song et al., 2021). It can be inferred from these studies that strength is associated with anaerobic performance. There are also studies examining the correlation between strength and physical variables like age, weight and gender (Brent et al., 2013; De Ste Croix et al., 2003; Harbo et al., 2012). When the literature is examined, although there are studies on young elite football players, there are not enough studies examining strength and anaerobic performance. The isokinetic strength test is a measurement method with high accuracy and validity (Tourny-Chollet et al., 2000; Wang et al., 2020). Low angular velocities are generally preferred to measure the maximal strength, while high angular velocities are preferred to determine stamina

in isokinetic tests. (Kabacinski et al., 2022). Isokinetic strength measurements provide information about performance, injury, and strength asymmetry of the athletes.

The main aim of present study was to investigate relationship between the anaerobic performance outputs and isokinetic strength values in elite youth male football player.

METHOD

Subjects

This study was carried out with Erzurum sports players in TFF U19 age group, U-19 Elite B league. Variables of the participants are shown in Table 1.

The participants were all free from chronic health problems and lower extremity disorders. Subjects were informed about the all process of test. The Declaration of Helsinki was signed by subjects. Ethical approval was obtained by the Atatürk University Sport Science Sub-Ethic Committe (No:38 Date:25.04.2023).

Study design

A cross-sectional design was used to examine the relationship between isokinetic strength and anaerobic performance. Evaluations of players were carried out in two occasions separated by 48-hour intervals. We applied two tests, anthropometric measurements and isokinetic knee strength test. On the first day, Anthropometric tests were completed by measuring body weight (with gym clothes, no shoes) and height (anatomical position), Isokinetic strength test was conducted to evaluate peak torque of knee flexor/extensor muscles. Peak torque was measured as it reflects the highest force output produced by maximal contraction in the range of motion of the joint (Andrade et al., 2022). Tests were performed on dominant and non-dominant sides. On the second day, a 30- second Wingate test was performed to assess anaerobic Peak Power (PP) and Relative Peak Power (RPP). Eating and drinking instructions were explained to the subjects before the tests and they were informed about the tests to be performed on each test day. Before laboratory visits, participants were instructed to almost 12-hours, refrain from training, caffeine intake for the pre 24-hours and no eat for the previous 3 hours. Anthropometric measurements, isokinetic strength tests and anaerobic performance test were carried out at Atatürk University Sports Sciences Application and Research Center. Temperature of the center was between 24 ^{o}C and the humidity was measured as 65%. The center is located at an altitude of 1890m in Erzurum.

Anthropometric measurements

The anthropometric measurements of the participants in this study were performed with the DESIS B5, which is 0.1 cm and 0.01 kg precision. Measurements were made in anatomical posture and head in the frontal plane (without shoes and in sportswear). Body mass index was calculated considering to the formula given below.

Formula: weight (kg) / height (m2)

Isokinetic strength test

Knee flexor and extensor muscles strength of the athletes was assessed with an isokinetic dynamometer (IsoMed 2000, Ferstl, Germany). The subjects were informed about test and the machine was introduced. Firstly, the subjects were recorded and adjustments were made from the isokinetic dynamometer according to the subject's anthropometric characteristics. In order to provide stabilization, the subjects were fixed to the machine in the sitting position with a belt from the waist region and with the help of a shoulder apparatus from the shoulder regions. In addition, the distal femur of the tested leg was fixed with a stabilization tape. Finally, the Lever apparatus was fixed to the tibia five centimetres above the malleoli (Uslu et al., 2021). Before starting each test, gravity calibration was done passively with the leg held at 90 degrees (full extansion). All test were performed dominant and non-dominant limb, respectively. The preferred leg when kicking the ball was considered as the dominant leg. Isokinetic measurements of the athletes were conducted for concentric contraction at 60º/sec (5 repetitions) (Barrera et al., 2023). The repetitions were performed through a range of 0–90°. Verbal encouragement and visual feedback was given to the participants during the measurement. The test was conducted by the same researcher. Prior to the test, participants were allowed 5 trials. The participants rested for 1-min between the sets.

Prior to test, participants warmed up on a bicycle ergometer (Wattbike Ltd., Nottingham, UK) for 10 minutes. They were ready for the test by performing static stretching exercises for the lower extremities. Peak Torque (PT) values were directly obtained from isokinetic dynamometer and Relative Peak Torque (RPT) was obtained by dividing the peak work values by body weight of the person.

Anaerobic performance test

To evaluate anaerobic performance, Wingate Cycle Ergometer (894 E, Monark, Sweden) was used. Handle and seat heights were set based on comfort of each participant. It was conducted concidering to usually accepted recommendations (Bar-Or, 1987; Song et al., 2021).

Prior to anaerobic performance test, subjects cycled 50 RPM with a resistance of 50 W for five minutes. After cycling warm-up, subjects took a 10-minute rest. The pedalling load was preferred to 7.5% of the weight of each subject. The subjects were instructed before the test to pedal as fast as possible for 30 second, and researcher verbally encouraged during the test to subjects. Once the RPM maximized, the pedalling load was applied (Junior et al., 2022). This test was applied once and Peak Power (PP) and Relative Peak Power (RPP) parameters were considered.

Statistical analysis

Statistical Package for the Social Sciences version 26.0 (SPSS Inc., IBM, Armonk, NY) used to analyze obtained datas. The results was presented as mean ± SDs. The normality of data was evaluated by Shapiro-Wilks. The correlation between isokinetic strength and anaerobic were showed using the Pearson correlation coefficient. Significant values for the statistical evaluation is $p< 0.05$.

RESULTS

Table 1. The subjects characteristics

Variables	**Mean ± SD** Total (n = 19)
Age (years)	18.42 ± 0.76
Height (cm)	180.79 ± 6.33
Weight (kg)	70.68 ± 8.18
BMI (kg/m^2)	21.57 ± 1.88

n: sample size; **SD:** standard deviation; **BMI:** body mass index

Tablo 2. Descriptive statistics of the knee muscle strength and anaerobic performance

Variables	**Mean ± SD**	
60^o/sec knee	Right Leg	Left Leg
Flexion PT (Nm)	146.96 ± 4.73	143.96 ± 5.27
Extension PT (Nm)	263.92 ± 8.31	260.72 ± 9.11
Flexion Relative PT (Nm/kg)	2.07 ± 0.02	2.03 ± 0.03
Extension Relative PT (Nm/kg)	3.73 ± 0.06	3.68 ± 0.06
Peak Power (W)	820.31 ± 31.34	
Relative Peak Power (W/kg)	11.64 ± 0.32	

Nm: newton meter; **PT:** peak torque; **SD:** standard deviation; **sec:** second; **W:** watt; **SD:** standard deviation

Tablo 3. Knee muscle strength and wingate anaerobic performance correlation

Variables		Right Leg	Left Leg	Right Leg	Left Leg
		Flexion PT		Extension PT	
Anaerobic Peak Power	r	0.686	0.596	0.735	0.585
	p-Value	0.001**	0.007**	0.000**	0.009**
		Flexion Relative PT		Extension Relative PT	
Relative Peak Power	r	0.364	0.093	0.538	0.056
	p-Value	0.125	0.704	0.018*	0.818

*p<0.05; **p<0.01

DISCUSSION AND CONCLUSION

This study examined the relationship isokinetic knee strength and Anaerobic performance in elite young soccer players (U-19s). Isokinetic strength tests were applied to the participants to evaluate their lower extremity strength, and the Wingate test was applied to determine their anaerobic power. The main findings of the present study were that peak torque of the athletes' knee extensor and flexor muscles at 60o/sec. and Wingate anaerobic peak power strongly related to each other and relative peak torque of right knee extensor muscles and anaerobic relative peak power were moderately related to each other. On the other hand, it was determined that there was no relationship between the relative peak torques of the flexor muscles of both feet and the relative peak torque values of the extensor muscles of the left leg and the anaerobic relative peak power values.

The findings of this study support the studies in the literature. So, there is a positive relationship between isokinetic muscle strength and anaerobic power. Blackburn and Morrissey (1998) stated that there was a moderate and high level of correlation between isokinetic strength and anaerobic power parameters, similar to this study. In another study, Kovaleski et al. (2001) revealed a low level of correlation between anaerobic power outputs and isokinetic strength of knee extensor muscles. Similarly, the same parameters are moderately and highly correlated with 180 degrees angular velocity (Dauty & Josse, 2004; Kabacinski et al., 2022). Malliou et al. (2003), reported a moderate and high correlation between anaerobic power parameters and isokinetic power outputs at both 60 and 180 angular velocities. Atabek and Sönmez (2009), indicated that there is a positive significant relationship between anaerobic power parameters and isokinetic muscle strength parameters in healthy young men. Harbili (2015), revealed that there is a relationship between isokinetic muscle strength at high angular velocity and anaerobic performance in soccer players. Yoo (2016), reported a significant relationship between right knee extensor muscles and anaerobic peak power in her study conducted with middle school soccer players but reported that there was no significant relationship between right knee flexors

and left knee extensor and flexor muscle groups. Strength is an output required for explosive power (Del Vecchio et al., 2019; Zhang et al., 2019). This may explain why isokinetic strength is associated with anaerobic performance. Strength affects many biomotor abilities as well as directly affects anaerobic power output. Depending on the increase in muscular potential, the strength generation mechanism also increases. This increases the level of aerobic and anaerobic performance markers. Therefore, the increase in power output also contributes to the increase in anaerobic power output.

There are studies in different sports (e.g., American football, basketball) examining the relationship between anaerobic performance and isokinetic strength. It is seen that there are similar results to soccer in different sports than soccer. However, studies have reported that there may be differences in the level of the relationship due to the skill specific to the sport, the anthropometric characteristics of the athletes, the physiological characteristics, and the difference in physical functions. it has been demonstrated that isokinetic muscle strength and anaerobic performances related to each other in American football players (Özkan & Kin Isler, 2010). Studies have stated that there is a relationship between isokinetic strength of extensor muscles and anaerobic performance of basketball players (Alemdaroğlu, 2012; Harbili, 2015). Kabacinski et al. (2022) examined the relationship between different anaerobic parameters and isokinetic muscle strength in their study and reported that there was no relationship between anaerobic power parameters at angular velocity and 60 degrees isokinetic strength. Ogata et al. (2000) stated that there was no significant relationship between isokinetic muscle strength and anaerobic power and reported that this might be due to age.

According to the results obtained from the current study, a positive correlation was found between the strength increase of both flexor and extensor muscles and the parameters of anaerobic power output. Anaerobic power is a very important parameter for performance in sports. It is thought that increasing the strength parameters for anaerobic power development will make positive contributions to performance. So, the increase in muscular strength significantly increases anaerobic power outputs. From this point of view, it should be known that strength development is the basis of the development of anaerobic power parameters of young football players. It is recommended that trainers and athletes perform training to increase their muscle strength to a sufficient level in the previous process in order to develop anaerobic power, especially in young age groups.

GENİŞLETİLMİŞ ÖZET

GİRİŞ

Futbol en yaygın takım sporları arasındadır ve popülaritesi tüm dünyada her geçen gün artmaktadır. Popüleritesinin yüksek olma sebebi her yaştan insanın başlangıç veya elit düzeyde oynayabilmesidir (Stølen ve ark., 2005). Futbolun popülaritesi, çok sayıda bilimsel çalışmada yer almasına da olanak sağlamıştır.

Futbol 90 dakikalık süre içerisinde değişen yoğunlukta ve aralıklı hareketler gerektiren bir oyundur (Yanci ve ark., 2016). Oyun boyunca kasların enerji ihtiyaçlarının karşılanması için aerobik ve anaerobik enerji mekanizmaları gereklidir (Meckel ve ark., 2009). Aerobik metabolizma, futbol oyununda enerji kullanımında yoğun bir şekilde gösterilmesine rağmen, sporcular oyunda anaerobik enerji sistemi tarafından sağlanan kısa süreli hareketleri (sprint, sıçrama, şut ve mücadele) gerçekleştirirler. Bu hareketler anaerobik kondisyonun yanı sıra alt ekstremitelerin patlayıcı güç ve kuvvetini gerektirdiği düşünülmektedir. Bu genellikle maçın çıktıları ve performansı için çok önemlidir (Stølen ve ark., 2005; Wragg ve ark., 2000). Bu nedenle, kas kuvveti ölçümleri genellikle oyuncularda anaerobik kondisyonun değerlendirilmesine dahil edilir (Yanci ve ark., 2016).

Bu çalışmanın temel amacı, elit genç erkek futbolcularda anaerobik performans çıktıları ile izokinetik kuvvet değerleri arasındaki ilişkiyi araştırmaktır.

YÖNTEM

Bu çalışma TFF U19 yaş grubu U-19 Elit B liginde yer alan Erzurumspor'da oynayan futbolcular ile gerçekleştirilmiştir.

İzokinetik güç ile anaerobik performans arasındaki ilişkiyi incelemek için kesitsel bir tasarım kullanılmıştır. Oyuncuların değerlendirilmesi 48 saat arayla iki kez gerçekleştirilmiştir. Antropometrik ölçümler ve diz izokinetik kuvveti testi olmak üzere iki test uygulanmıştır. Antropometrik testler başlangıçta vücut ağırlığı (spor kıyafeti ile, ayakkabısız) ve boy (anatomik pozisyon) ölçülerek tamamlanmış, diz fleksör/ekstansör kaslarının zirve torkunu değerlendirmek için İzokinetik kuvvet testi uygulanmıştır. Zirve tork, eklemin hareket aralığındaki maksimum kasılma ile üretilen en yüksek kuvvet çıkışını yansıttığı için ölçülmüştür (Andrade ve ark., 2022). Testler her diz için dominant ve nondominat taraf olarak yapıldı. İkinci gün, anaerobik zirve gücünü (PP) ve relative zirve gücünü (RPP) değerlendirmek için 30 saniyelik Wingate testi yapılmıştır. Deneklere testlerden önce yeme-içme talimatları anlatılmış ve her test gününde yapılacak testler hakkında bilgi verilmiştir. Sirkadiyen ritim etkisini elimine etmek için bütün sporcular günün aynı saatinde test edilmiştir. Sporculardan testlerden 12 saat önce önce herhangi bir antrenman yapmamaları, 24 saat önce kafein almamaları ve testlerden en az 3 saat öncesinde yemek yemeyi kesmeleri istenmiştir. Tüm testler Atatürk Üniversitesi Spor Bilimleri Uygulama ve Araştırma Merkezi'nde gerçekleştirilmiştir. Merkezin içinde bulunan laboratuvaın

sıcaklığı 24 ºC arasındaydı ve nem %65 olarak ölçülmüştür. Merkez Erzurum'da 1890m rakımda bulunmaktadır.

Elde edilen verilerin analizinde Statistical Package for the Social Sciences version 26.0 (SPSS Inc., IBM, Armonk, NY) kullanılmıştır. Sonuçlar ortalama ±SD olarak sunuldu. Verilerin normalliği Shapiro-Wilks tarafından değerlendirilmiştir. İzokinetik kuvvet ve anaerobik arasındaki ilişki, Pearson korelasyonu kullanılarak gösterilmiştir. İstatistiksel değerlendirme için anlamlılık değeri $p<0,05$'tir.

TARTIŞMA

Bu çalışmanın bulguları literatürdeki çalışmaları desteklemektedir. Yani izokinetik kas kuvveti ile anaerobik güç arasında pozitif bir ilişki vardır. Blackburn ve Morrissey (1998), izokinetik kuvvet ile anaerobik güç parametreleri arasında bu çalışmaya benzer şekilde orta ve yüksek düzeyde korelasyon olduğunu belirtmişlerdir. Başka bir çalışmada Kovaleski ve arkadaşları (2001), anaerobik güç çıktıları ile diz ekstansör kaslarının izokinetik kuvveti arasında düşük düzeyde bir korelasyon ortaya koymuşlardır. Benzer şekilde, aynı parametreler 180 derece açısal hız ile orta ve yüksek düzeyde ilişkilidir (Dauty & Josse, 2004; Kabacinski ve ark., 2022). Malliou ve arkadaşları (2003), hem 60 hem de 180 açısal hızlarda anaerobik güç parametreleri ile izokinetik güç çıktıları arasında orta ve yüksek bir korelasyon bildirmiştir. Atabek ve Sönmez (2009), sağlıklı genç erkeklerde anaerobik güç parametreleri ile izokinetik kas kuvveti parametreleri arasında pozitif yönde anlamlı bir ilişki olduğunu belirtmişlerdir. Harbili (2015), futbolcularda yüksek açısal hızdaki izokinetik kas kuvveti ile anaerobik performans arasında bir ilişki olduğunu ortaya koymuştur. Yoo (2016), ortaokul futbolcuları ile yaptığı çalışmasında sağ diz ekstansör kasları ile anaerobik tepe gücü arasında anlamlı bir ilişki olduğunu bildirmiş ancak sağ diz fleksör kasları ile sol diz ekstansör ve fleksör kas grupları arasında anlamlı bir ilişki olmadığını bildirmiştir. Kuvvet, patlayıcı güç için gerekli bir çıktıdır (Del Vecchio ve ark., 2019; Zhang ve ark., 2019). Bu, izokinetik kuvvetin neden anaerobik performansla ilişkili olduğunu açıklayabilmektedir. Antrenör ve sporcuların özellikle genç yaş gruplarında anaerobik gücü geliştirmek için önceki süreçte kas kuvvetlerini yeterli düzeye çıkaracak antrenmanlar yapmaları önerilir.

SONUÇ

Bu çalışma, elit genç futbolcularda (U-19) izokinetik diz kuvveti ile anaerobik performans arasındaki ilişkiyi incelemiştir. Katılımcılara alt ekstremite kuvvetlerini değerlendirmek için izokinetik kuvvet testler, anaerobik güçlerini belirlemek için Wingate testi uygulanmıştır. Bu çalışmanın ana bulgularına bakıldığında sporcuların diz ekstansör ve fleksör kaslarının 60º/sn'deki zirve torkunun ve Wingate anaerobik zirve gücünün birbiriyle güçlü bir şekilde ilişkili olduğu ve sağ diz ekstansör kaslarının relative zirve torku ile anaerobik relative zirve gücünün orta derecede ilişkili olduğu görülmektedir. Öte yandan her iki ayak fleksör kaslarının rölatif tepe torkları ile sol diz ekstansör kaslarının rölatif zirve tork değerleri ve anaerobik rölatif zirve güç değerleri arasında ilişki olmadığı belirlenmiştir.

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Tasarım *Design*	Yöntem ve araştırma desenini tasarlamak *To design the method and research design.*	Kemalettin SEREN Gökhan ATASEVER
Literatür Tarama *Literature Review*	Çalışma için gerekli literatürü taramak *Review the literature required for the study*	Hasan Hüseyin YILMAZ Gökhan ATASEVER
Veri Toplama ve İşleme *Data Collecting and Processing*	Verileri toplamak, düzenlemek ve raporlaştırmak *Collecting, organizing and reporting data*	Kemalettin SEREN Gökhan ATASEVER
Tartışma ve Yorum *Discussion and Commentary*	Elde edilen bulguların değerlendirilmesi *Evaluation of the obtained finding*	Hasan Hüseyin YILMAZ Kemalettin SEREN Gökhan ATASEVER

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