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Investigation of the Relationships between Isokinetic Leg Strength, Sprint and Agility Performance in Collegiate American Football Players

Üniversiteli Amerikan Futbolu Oyuncularında İzokinetik Bacak Kuvveti, Sprint ve Çeviklik Performansı Arasındaki İlişkilerin İncelenmesi

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ABSTRACT

Objective: The purpose of this study was to investigate the relationship between absolute isokinetic knee flexion and extension strength, and sprint and agility performance in collegiate male American Football players.

Materials and Methods: Twenty-six collegiate male players aged 19-27 years with at least a year of experience in playing American Football participated in the study. The players were tested for absolute isokinetic knee flexion and extension peak torque, sprint, and agility performance over two different days with at least 72-hour rest interval between tests. Knee flexion and extension peak torque were measured by means of an isokinetic dynamometer (HUMAC NORM, USA) at angular velocities of $60°\cdot s^{-1}$, $150°\cdot s^{-1}$, and $300°\cdot s^{-1}$ for both knees. Sprint performance was evaluated with 40-yard dash and agility was evaluated with pro-agility tests, respectively.

Results: The study demonstrated that 40-yard dash and pro-agility test results did not correlate with any measures of isokinetic knee flexion and extension peak torque ($p>0.05$).

Conclusion: The results of this study indicate that isokinetic knee flexion and extension peak torque are not good predictors of sprint and agility performance in male collegiate American Football players. Additional research that will also evaluate relative ($Nm.kg^{-1}$) isokinetic strength may be required to elucidate whether a correlation between isokinetic strength, and sprint and agility performance or perhaps other measures of performance exist for American Football players.

Keywords: American Football, isokinetic strength, sprint, agility

ÖZ

Amaç: Bu çalışmanın amacı, üniversiteli erkek Amerikan Futbolu oyuncularında izokinetik diz fleksiyon ve ekstansiyon mutlak kuvveti ile sprint ve çeviklik performansı arasındaki ilişkilerin araştırılmasıdır.

Gereç ve Yöntemler: Çalışmaya, en az bir yıllık Amerikan Futbolu deneyimi olan 19-27 yaş aralığında 26 erkek Amerikan Futbolu oyuncusu katıldı. Oyuncular, en az 72 saat arayla iki farklı günde izokinetik diz fleksiyon ve ekstansiyon mutlak zirve tork kuvveti, sprint ve çeviklik performansı açısından test edildi. Diz fleksiyon ve ekstansiyon zirve tork kuvveti (HUMAC NORM, USA) izokinetik dinamometre ile $60°\cdot s^{-1}$, $150°\cdot s^{-1}$ ve $300°\cdot s^{-1}$ 'lik açısal hızlarda her iki dizde ölçüldü. Oyuncuların sprint ve çeviklik performansları sırasıyla 40 yard sprint testi pro-agility testi ile değerlendirildi.

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Bulgular: Çalışma, 40 yarda sprint testi ve "pro-agility" testi sonuçları ile herhangi bir izokinetik diz fleksiyon ve ekstansiyon zirve tork kuvveti arasında korelasyon olmadığını gösterdi (p>0.05).

Sonuç: Çalışmanın sonuçları Üniversiteli erkek Amerikan Futbolu Oyuncularında izokinetik diz fleksiyon ve ekstansiyon zirve tork kuvvet değerlerinin, sprint ve çeviklik performansı için iyi bir belirteç olmadığını gösterdi. Amerikan Futbolu oyuncularında izokinetik kuvvet ile sprint ve çeviklik performansı arasında korelasyon olup olmadığının açıklanabilmesi için bağıl izokinetik kuvveti değerlendirecek (Nm.kg^{-1}) ek çalışmalar gerekmektedir.

Anahtar Sözcükler: Amerikan Futbolu, izokinetik kuvvet, sprint, çeviklik

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INTRODUCTION

The popularity of American Football (AF) is growing in many countries including countries such as Turkey, Northern Cyprus, Finland, Japan, Brazil, and the United States (1,2). AF is characterized athletically by rapid acceleration, high running speeds, jumping ability, explosive muscle force, speed endurance, a high demand for strength endurance, a powerful throw, and deceleration after performing complex skills such as cutting, catching the ball or passing. Despite of the high collision and injury rates, popularity and excitement of AF might be attributed to these characteristics of the sport (1,3,4).

The physical demands of AF include strength, speed, power, agility, flexibility, and aerobic and anaerobic endurance (3). According to McGee and Burkett; power, speed, and agility are valid predictors of draft status in professional AF players (5). Furthermore, muscular strength and speed are generally accepted to be major factors influencing AF player performance (6). It has been reported that greater strength is associated with enhanced force-time characteristics (e.g. rate of force development and capability of producing external mechanical power), general athletic performance (jumping, sprinting and change of direction) and sport-specific skill performance, and decreased injury rates (7). Measurement of muscle strength is an important factor in the evaluation and prediction of muscular condition in addition to functional capacity (8), which includes strength testing protocols utilizing dynamic, isometric or isokinetic methods (9). Isokinetic peak torque assessment is one of the most commonly applied methods of evaluating muscular condition in addition to functional capacity (8), isokinetic dynamometry generally being accepted as the gold standard for the assessment of isokinetic strength (10).

Although the isokinetic dynamometer is commonly used for the assessment of isokinetic strength, there are some controversial issues directed at the use of isokinetic testing and the isokinetic dynamometer. These include (9-14): a) high cost of isokinetic dynamometers as testing devices, b) proper training of the staff who will be operating the dynamometer, c) time required for familiarization to the device for a subject using before actual testing, d) weak correlation between isokinetic strength level and dynamic or functional performance of the subject (e.g. speed, agility, vertical jump, etc.), e) limitation of single joint measurement during isokinetic testing (whereas dynamic or functional performance tests assess multi-joint strength), f) isokinetic machinery allowing only open-chain exercises to be performed; whereas sport specific tests are able to include closed chain movements.

Due to these controversial issues surrounding isokinetic testing, some researchers began assessing the correlation between isokinetic peak torque and functional sport specific tests (e.g. squats, sprints, agility movements, vertical jumping, and standing long jump) (14-25). González-Ravé et al. reported no relationship between isokinetic knee flexion and extension peak torques and vertical jumping performance in elite handball players (15). A study that evaluated anaerobic performance through 10-m and 30-m sprints, vertical jumping height, and kicking performance tests in soccer players reported that there was no correlation between dominant leg flexion and extension peak torque and anaerobic performance (16).

However, İnal, Erbuğ and Kotzamanidis reported that the average isokinetic peak torque of the right dorsiflexors of female sprinters at $120°·s^{-1}$ was related to 100-m sprint times (17). A systematic review also reported that isokinetic strength testing has a strong potential to predict dynamic capabilities (e.g. 1 repetition max (RM) squat, bench press, sprint time, vertical jump and standing broad jump) in activities involving strength and explosive power (9). Given these conflicting results pertaining to the relationship between isokinetic strength and functional sport testing, the purpose of this study was to investigate the relationships between isokinetic leg strength and sprint and agility performance in collegiate AF players.

MATERIAL and METHODS

Subjects

Twenty-six collegiate AF players aged 19-27 years; from the Eastern Mediterranean University playing for the university's AF team participated in the study on a voluntary basis, and signed an informed consent form on the first session of the study. After the announcement, 34 AF players approached the researchers to participate. However, eight players were excluded due to their AF experience being less than a year. The number of players required for this study was based on the study of Tsiokanos et al. to ensure sufficient statistical power (18). Therefore, a simple size of 20 players was necessary to achieve 80% power (effect size=0.55, α=0.05, power=0.80). Ethical approval for this study was obtained from the Ethics Review Committee of Eastern Mediterranean University (Approval code: 2019/14-04). Limb dominance was defined as the leg that is preferred when kicking a ball (8). All of the players were right-leg dominant.

Inclusion criteria was determined as follows: a) to be >18 years old; b) to have a minimum AF experience of >1 year; c) to be actively playing collegiate football in a University's AF team; and d) not to have a history of musculoskeletal, neurologic, or cardiorespiratory complaints in the past six months. The players were instructed not to consume performance-enhancing substances (e.g. creatine, ribose etc.) and coffee was limited to one cup prior to testing. The players were also told not to engage in high-intensity physical activity 24 hours prior to the tests. The study consisted of two different testing days with at least a 72-hour interval.

Testing

On the first session, subjects were informed about the study protocol, descriptive and physical characteristics were collected in addition to performing the 40-yard dash and pro-agility field tests. On the second session, subjects performed an isokinetic knee flexion/extension peak torque test at the three different angular velocities of $60°·s^{-1}$, $150°·s^{-1}$ and $300°·s^{-1}$.

Body mass and height: Body mass and height were measured by a body composition analyzer (Tanita MC 980 MA, Japan) and telescopic height measuring scale (ADE, Germany).

40-yard dash test (36.6 m): Subjects performed a 10-min running warm-up before the sprint test. Even though running pace was determined by the subjects during this warm-up run, they were instructed to run with minimal or jogging speed. Before the actual test, each subject performed two submaximal sprints as part of the warm-up. Three minutes' rest was given between the warm-up and actual test attempts. Each subject ran two maximal 40 yard dashes within a 3 min rest interval. The best sprint time was recorded for evaluation.

Pro-agility test (18.3 m): Before the maximal tests, subjects attempted two submaximal runs. Subjects first ran 5 yds to the right, followed by 10 yard to the left, for a total of 20 yard (Figure 1). After 3 min rest, each subject ran three maximal pro-agility runs within a 3 min time interval from a three-point starting position. The best shuttle run time was recorded for evaluation. Directions were reversed for the second trial. Subjects decided the initial direction before the third attempt (26). During the test, subjects were warned to touch the lines with their hands. In cases where the subjects did not touch the line, the attempt was cancelled (27).

Sprint and shuttle run tests were measured with an infra-red gate timing device (Newtest 300 Series Power Timers, Oy, Finland). Both the 40-yard dash and pro-agility tests were carried out on a synthetic track at the university's track & field facility. The order of the tests was randomized, where some players started with the pro-agility test, whereas others started with the 40-yard dash.

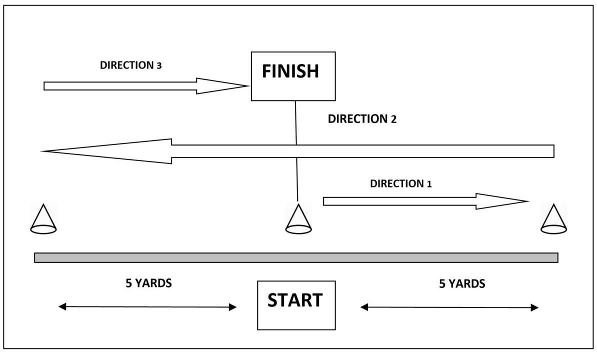

Figure 1. Pro-agility test

Isokinetic testing: After a warm-up consisting of 10 min running on a motor-driven treadmill at self-selected speed (max speed limit: 6.0 km/h), subjects were properly positioned in the isokinetic dynamometer (HUMAC NORM Isokinetic Extremity System, MA, USA). They performed a set of five consecutive extension-flexion contractions in the concentric-concentric mode at $60°·s^{-1}$, $150°·s^{-1}$ and $300°·s^{-1}$. They also performed two sub-maximal trials before performing a set of five maximal efforts at each angular velocity. Testing of dominant and non-dominant legs was separated with a 3 min resting period. A 2 min rest separated the measurements at different velocities. Subjects were tested from low to high angular velocity. Tests began with the dominant leg (right) and were completed with the non-dominant (left). They were asked to perform maximal voluntary contractions bilaterally. To ensure maximal effort and contraction, subjects were verbally encouraged throughout the testing. The highest peak torque (Nm) obtained from each test was selected for statistical analysis.

Statistical Analysis

SPSS 23.0 (SPSS, Chicago, IL, USA) software was used for statistical analysis. Data conformity to normal distribution was assessed using the Shapiro-Wilk test. Normally distributed data was presented as mean ± standard deviation (SD), non-normal distribution data was expressed as medians (25-75 percentiles). Correlations between isokinetic knee flexion and extension strength, sprint, and agility performance were assessed using the Pearson product moment correlation coefficient and Spearman's rank correlation coefficient for normally- and non-normally distributed data, respectively. The level of statistical significance was set at $p<0.05$.

RESULTS

Descriptive statistics, peak isokinetic concentric knee flexion, and extension torque of the subject are presented in Tables 1 and 2. Data from the 40-yard dash and pro-agility tests are given in Table 3. Correlations between peak isokinetic concentric knee flexion and extension peak torque tests, and the 40-yard dash and pro-agility tests are presented in Table 4. As shown, no correlation was found between isokinetic concentric knee flexion and extension torque and either the 40-yard dash or pro-agility tests ($p>0.05$).

Table 1. Descriptive characteristics of the subjects

Variables	Mean ± SD/Medians (25-75%)
Age (yr)	22.0 (19-27)†
Sport experience (yr)	2.0 (1-6)†
Height (cm)	181.5 ± 0.8
Body mass (kg)	86.0 (69-140)†

SD: standard deviation; †: non-parametric variables calculated as 25-75 | percentiles and shown as (min-max)

Table 2. Peak isokinetic concentric knee flexion and extension torques

Extremity	Isokinetic test	Mean ± SD/Medians (25-75%)
Right leg	60°·s^{-1} Flexion	153.3 ± 29.7
	60°·s^{-1} Extension	258.4 ± 58.0
	150°·s-1 Flexion	117.0 (31-148)†
	150°·s^{-1} Extension	171.0 (35-228)†
	300°·s^{-1} Flexion	72.1 ± 25.5
	300°·s^{-1} Extension	92.4 ± 29.6
Left leg	60°·s^{-1} Flexion	146.0 ± 38.0
	60°·s^{-1} Extension	235.2 ± 58.1
	150°·s^{-1} Flexion	115.0 ± 26.3
	150°·s^{-1} Extension	167.4 ± 36.5
	300°·s^{-1} Flexion	74.9 ± 23.4
	300°·s^{-1} Extension	97.8 ± 24.3

In N-m units; †: non-parametric variables as 25-75% (min-max)

Table 3. Results of the 40-yard dash and pro-agility tests

Tests	Medians (25-75%)
Pro-agility test (s)	5.6 (5.4-6.4)†
40-yard dash test (s)	5.3 (4.7-6.4)†

†: non-parametric variables as 25-75 percentiles (min-max)

DISCUSSION

This study investigated the relationship between isokinetic leg strength, and sprint and agility performance in collegiate AF players. One of the most important findings of this study was that, when evaluated at different velocities (60°·s^{-1}, 150°·s^{-1}, and 300°·s^{-1}), no relationship was found between peak isokinetic concentric knee flexion and extension torque and 40-yard dash or pro-agility test performance. Based on the review of existing literature, we found no studies that attempted to explain the relationship between isokinetic leg strength and sprint and agility performance in collegiate AF players. Therefore, the results of the present study were discussed by comparing it with other sports such as handball, basketball and soccer.

Table 4. Correlations between peak isokinetic concentric knee flexion and extension peak torque and the 40-yard dash and pro-agility tests

		Right leg		Left leg	
Tests		**r**	**p**	**r**	**p**
Pro-agility test	60°·s-1 Flexion	0,034	0,868	0,001	0,996
	60°·s-1 Extension	0,235	0,247	0,211	0,300
	150°·s-1 Flexion	0.004¥	0,491	-0,103	0,618
	150°·s-1 Extension	0.327¥	0,051	0,119	0,563
	300°·s-1 Flexion	-0,064	0,755	-0,040	0,846
	300°·s-1 Extension	0,005	0,979	0,231	0,256
40-yard dash test	60°·s-1 Flexion	0,226	0,266	0,066	0,748
	60°·s-1 Extension	0,157	0,445	-0,017	0,934
	150°·s-1 Flexion	0,020	0,462	-0,064	0,755
	150°·s-1 Extension	0,068	0,371	-0,013	0,946
	300°·s-1 Flexion	0,103	0,616	0,335	0,095
	300°·s-1 Extension	-0,139	0,497	0,259	0,202

***r:** correlation coefficient; **¥:** correlation coefficient for non-parametric data*

Similar to our results, Alemdaroglu reported that there was no significant relationship between knee strength (flexion and extension at 60°·s^{-1} and 180°·s^{-1}) and field testing (10 m and 30 m sprinting, T-drill agility test, squat jump and counter-movement jump tests, etc.) in basketball players (19). Cometti et al. also reported that there was 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, ball speed, squat jump and counter-movement jump tests, etc.) in elite, subelite and in amateur French soccer players (16). Another study reported that there was no relation between isokinetic knee flexion and extension peak torques (60°·s^{-1} and 180°·s^{-1}) and jump performance (squat jump and counter-movement jump) in elite handball players (15).

On the other hand, some researchers have reported that there may exist relationships between isokinetic knee flexion/extension torque and sprint, agility, jumping, kicking or throwing performance (2,6,20-25). Brooks, Clark and Dawes reported significant relationships between isokinetic peak muscle torque, agility (Illinois agility test), ball velocity and vertical jump (28). Another study reported relationship between isokinetic strength and anaerobic power (Wingate Anaerobic Power test-WAnT) in male collegiate AF players (2). Accordingly, there were relationships between concentric knee extension peak torque and anaerobic performance (both peak power and mean power), when tested at different angular velocities (60°·s^{-1}, 150°·s^{-1} and 300°·s^{-1}).

However, further studies have reported mixed results pertaining to the relationship between isokinetic strength, change of direction (COD) and agility performance (T-test and 505 test) (24). According to Spiteri et al. (24), there is strong correlation between isometric strength and COD performance in female athletes, whereas there is no relationship between isometric strength and agility performance.

As noted above, there are contradictory results addressing any relationship between isokinetic knee muscle peak torque and functional performance in sport science literature. These contradictory results may be caused by several factors including: age, gender, training experience and level, sport specificity, specificity of the isokinetic testing protocol (e.g. test position, muscle contraction type, testing angular velocities, etc.), inconsistency between isokinetic testing and functional testing in terms of movement patterns (e.g. single joint, multi-joint, single plane, open kinetic chain or closed kinetic chain, etc.), and inconsistency between isokinetic testing and functional testing in terms of energy systems (6,15,19,23,24,29).

González-Ravé et al. (15) reported no relationship between isokinetic knee flexion and extension peak torques and vertical jumping performance in elite handball players. The authors explained the results such that vertical jumping is a closed chain, multi-joint task involving a stretch-shortening cycle type motion and that its neuro-muscular coordination aspect of affects skill significantly, whereas isokinetic testing is an open kinetic chain test at a constant angular velocity dictated by the machine. Newman et al. (6) reported that there were no relationships between isokinetic knee flexion and extension peak torques and anaerobic performance when evaluated by repeated sprint tests (12x20 m, with a 20 s resting interval). The phosphate system (ATP-CP) is the dominant energy system in isokinetic testing, whereas the dominant energy system in repeated sprint testing is the glycolytic energy system (lactic anaerobic system) accompanying the ATP-CP system.

When examining the results of this study, it should be noted that there is no inconsistency in terms of movement patterns between the tests; isokinetic testing, 40-yard dash, and pro-agility are all open kinetic chain movement patterns. Furthermore, there is also no difference in energy system utilization between the tests as the energy system is predominantly the ATP-CP system. Therefore, we cannot conclude what might be the precise reason for the lack of relationship between isokinetic leg strength and sprint and agility performance tests in this study on collegiate AF players. However, we suggest that other factors, such as training status and sport experience and single vs. multi-joint movement patterns, may have had an impact on the results of the present study.

The results of the present study should be evaluated with its limitations. The major limitation of the study was testing the absolute peak torque instead of relative peak torque (Nm.kg^{-1}). It was also noticed that sprinting and agility performances were affected by body mass. Future studies should take these factors into consideration.

To conclude; the present study did not confirm any correlation between isokinetic strength of knee flexors and extensors, and sprint and agility performance. The results of this study indicate that isokinetic knee flexion and extension peak torque might not be good predictors of sprint and agility performance in male collegiate AF players. As mentioned above, further investigations evaluating relative isokinetic strength to elucidate whether there is any correlation between isokinetic strength and sprint and agility performance in AF players might prove to be beneficial.

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