

The Relationship Between Lower Extremity Strength, Anaerobic Power and Change of Direction Speed in Female Basketball Players

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Abstract

The purpose of this study is to examine the relationship between lower extremity strength, anaerobic power, and change-of-direction speed in female basketball players. Twenty-nine well-trained young female basketball players aged 14-20 (mean $\pm$ SD; age: 15.48 ± 1.81 years; body weight: 65.70 ± 12.48 kg; and height: 175.90 ± 7.50 cm) voluntarily participated in the study. This study was conducted during a period when there were no competitive games (off-season). The study was conducted in 3 different sessions, each 48 hours apart. Participants underwent measurements of body composition, isokinetic knee extension and flexion strength, anaerobic power (Wingate Test, WAnT), and change of direction speed (CoDs, T-test). Normality analysis (Shapiro-Wilk) was performed for data analysis. The relationships between lower extremity isokinetic strength, anaerobic power, and change of direction speed were analyzed using Pearson's correlation test. A significant relationship was found between right knee extension, right knee flexion, left knee extension, and left knee flexion isokinetic values and absolute peak power ($p < 0.05$). A significant relationship was observed between absolute peak power and CoDs ($p < 0.05$). In conclusion, this study found that lower extremity isokinetic strength is an important parameter for predicting anaerobic power performance (absolute and relative peak power) but is not a good predictor of change of direction performance.

Keywords: Isokinetic Strength, anaerobic power, change of direction speed, basketball.

Özet

Kadın Basketbolcularda Alt Ekstremitte Kuvveti, Anaerobik Güç ve Yön Değiştirme Hızı Arasındaki İlişki

Bu çalışmanın amacı, kadın basketbolcularda alt ekstremitte kuvveti, anaerobik güç ve yön değiştirme hızı arasındaki ilişkinin incelenmesidir. Çalışmaya, 14-20 yaş arasında iyi antrenmanlı 29 genç kadın basketbolcu (ortalama $\pm$ SD; yaş: $15,48 \pm 1,81$ yıl; vücut ağırlığı: $65,70 \pm 12,48$ kg; ve boy: $175,90 \pm 7,50$ cm) gönüllü olarak katıldı.. Bu çalışma rekabetçi maçların olmadığı bir zamanda (devre arası dönemde) yapıldı. Çalışma her biri arasında 48 saat olan 3 farklı seansta gerçekleştirildi. Çalışmada katılımcılara vücut kompozisyon, izokinetik diz ekstansiyon ve fleksiyon kuvveti, anaerobik güç (Wingate Testi, WAnT) ve yön değiştirme hızı (T testi) ölçümleri uygulandı. Verilerin analizinde normallik analizi (Shapiro-wilk) yapıldı. Alt ekstremitte izokinetik kuvveti, anaerobik güç ve yön değiştirme hızı arasındaki ilişkiler Pearson korelasyon testi ile analiz edildi. Sağ diz ekstansiyon, sağ diz fleksiyon, sol diz ekstansiyon ve sol diz fleksiyon izokinetik değerleri ile mutlak zirve güç arasında anlamlı ilişki tespit edildi. ($p<0.05$). Mutlak zirve güç ile yön değiştirme hızı arasında anlamlı ilişki olduğu görüldü ($p<0.05$). Sonuç olarak, bu çalışma, alt ekstremitte izokinetik kuvvetinin anaerobik güç performansını (mutlak ve göreceli tepe güç) öngörmeye önemli bir parametre olduğunu, ancak yön değiştirme performansındaki değişimi öngörmeye iyi bir gösterge olmadığını ortaya koymuştur.

Anahtar Kelimeler: İzokinetik kuvvet, anaerobik güç, yön değiştirme hızı, basketbol.

INTRODUCTION

Basketball is a physically demanding team sport involving high-intensity activities such as sprinting, running in different directions, walking, shooting, dribbling, jumping, decelerating, and accelerating. In basketball, players must repeatedly perform many activities with very short breaks during competition, so they need to be physically well-prepared by training their strength, power, change of direction, aerobic, and anaerobic capacities appropriately (1, 2). During a game, players make approximately 550 to 1000 changes in direction and speed and 40-60 maximal jumps, depending on their level and position. The high number of low- and high-intensity activities highlights the importance of physical characteristics in basketball. To gain positional advantages, perform repetitive movements at a high level, and effectively execute ball-handling/ball-less direction changes, which are determinants of game performance, a combination of fundamental characteristics such as strength, power, and anaerobic capacity is required (2, 3).

Change of direction speed is one of the most important performance parameters required for success in basketball, as in many other sports (4, 5). It is a common athletic performance indicator that athletes need to evade or pursue their opponents (3). Researchers suggest that the key determinants of change of direction ability include characteristics such as technique, speed, strength, and power (5). It has also been noted that, along with the ability to change direction, many movements requiring high jumping, such as slam dunks, rebounds, and blocks, which are fundamental movements in basketball, can only be performed well if the lower extremity muscles (especially the quadriceps, hamstring, gluteal, and gastrocnemius groups) are strong. One of the most valid and reliable methods for measuring the strength and power potential of the lower extremities is isokinetic dynamometers (6).

Most researchers suggest that basketball is primarily dependent on anaerobic metabolism (7) and that anaerobic power is one of the determinants of high performance (8). Therefore, effective training methods that enhance the anaerobic capacity of basketball players are needed to improve their performance (9). Studies have reported that the 30-second anaerobic power cycling test is an effective and accurate assessment method (10).

Coaches aim to increase physical performance outputs such as strength, power, and change of direction speed by using various training methods. Although many previous studies have suggested a strong relationship between strength, power, and change of direction speed performance (11-14), there are also studies that have obtained opposite results and suggest that there is no relationship between these parameters (3, 15, 16). Due to this inconsistency in the results of the studies, there is uncertainty about how strength, power, and change of direction are related to each other. Furthermore, studies have generally examined the relationship between force and power, force and change of direction speed, or power and change of direction speed, and it has been observed that the number of studies examining all three parameters together is limited.

It is believed that this study is important in terms of addressing these limitations and helping coaches improve athletes' performance.

Therefore, the aim of this study is to examine the relationship between lower extremity strength, anaerobic power, and change of direction speed in female basketball players. It is hypothesized that there will be a high level of positive correlation between lower extremity strength, anaerobic power, and change of direction speed performance.

METHOD

Research Model

A descriptive correlational design was used in this study to examine the existence and direction of the relationship between three different performance parameters (lower extremity isokinetic strength, anaerobic power, change of direction speed). Correlation studies are conducted to determine the existence or degree of change between two or more independent variables (17).

Participants

Twenty-nine (29) well-trained young female basketball players aged 14–20 voluntarily participated in this study (mean $\pm$ SD; age: 15.48 ± 1.81 years; body weight: 65.70 ± 12.48 kg; and height: 175.90 ± 7.50 cm). The sample size to be included in the study was estimated in advance using the G*Power (3.1.9.7) program. It was determined that a total of 23 participants were needed to detect a moderate r value with a 95% confidence interval and an 80% statistical power assumption. Studies by Boraczyński et al. (18) and Yılmaz et al. (6) also served as references for the sample size. All athletes participating in the study attended basketball training 4 days a week, each lasting approximately 120 minutes, resistance training twice a week for approximately 60 minutes, and played one official game. Athletes who had any injuries in the 3 months prior to the start of the study and who did not regularly attend training/tests were not included in the study. All participants were informed about the objectives of the study and their right to withdraw from the study at any time. Written informed consent was obtained from all participants and their families before the start of the study. The study was approved by the Ethics Committee and complied with the recommendations of the Declaration of Helsinki.

Study Procedure

This study was conducted during a period when there were no competitive matches (mid-season break). The study was carried out in three separate sessions, each 48 hours apart. A familiarization session was conducted one week prior to the start of the study to introduce the tests and prevent any learning effect (45). Participants' body composition measurements (body weight and height) were also taken during the familiarization session. Isokinetic strength tests were administered to the athletes on the first measurement day (session 1). Then, the anaerobic power test (Wingate Test, WAnT) was administered in session 2. Finally, a change of direction speed test (CoDs, T test) was administered in session 3 (Figure 1). A standard warm-up was performed before all performance tests. The standard warm-up lasted a total of 15 minutes and consisted of 7 minutes of low-intensity running at a pace determined by the participants themselves and 8 minutes of dynamic stretching. The tests were conducted by the researcher in strict accordance with the appropriate protocols. All performance tests were conducted during the same time slot of the day (3:00 PM to 5:00 PM) to prevent the circadian rhythm from affecting performance. Body composition measurements were taken between 8:00 AM and 10:00 AM. Participants were asked to refrain from strenuous exercise during the tests and to maintain their normal diet and sleep patterns. Participants were also required to wear the same athletic shoes for all performance tests. All tests were conducted under the same environmental conditions (temperature 22–24°C, humidity 50–55%).

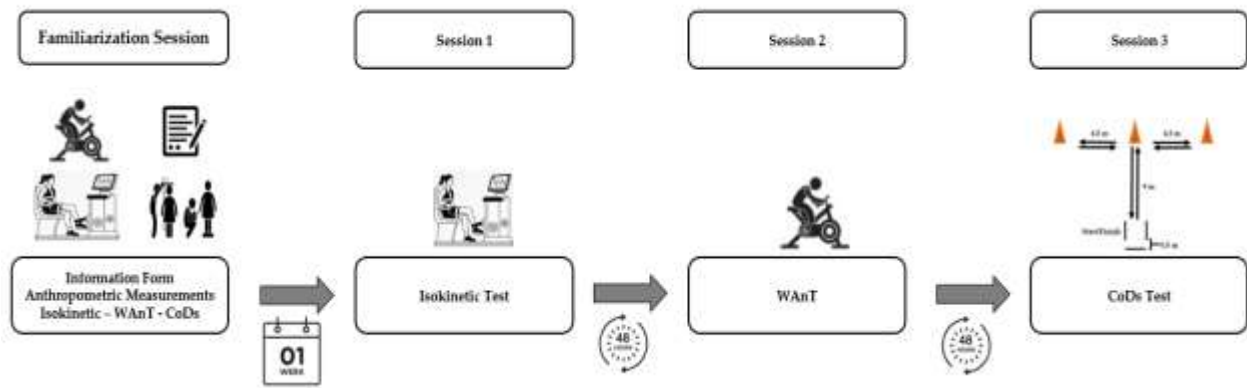


Figure 1. Study Design

Data Collection Tools

Body Composition Measurements

Participants' body weights were measured using an electronic scale (Tanita BC-418, Japan) with a sensitivity of 0.1 kg, and their heights were measured using a wall-mounted stadiometer (SECA, Germany) with a sensitivity of 0.5 cm. Both measurements were taken without shoes (46).

Isokinetic Strength

Participants' strength measurements were performed using a Cybex Norm II (Cybex Humac Norm, CSMI, Stoughton, MA, USA) isokinetic dynamometer. Each participant's knee extensor and flexor strengths were measured for both the right and left legs. Following a standard warm-up, participants sat in the dynamometer chair and were secured with straps at the torso, pelvis, and thigh regions according to test criteria. The knee joint was determined using the lateral femoral epicondyle as a reference, and the knee joint range of motion (ROM) was set from 0° (extension) to 90° (flexion). The dynamometer arm was fixed just above the lateral malleolus. Gravity correction was performed for all participants, and participants' dominant legs were tested first. After the necessary adjustments, participants performed a non-maximal preparation/warm-up phase of 10 repetitions at an angular velocity of 300°/s. This was followed by a 1-minute rest period, and the strength test was performed at an angular velocity of 60°/s for 5 maximal repetitions. After the dominant side was tested, a 2-minute rest period was provided to make the necessary adjustments, and the non-dominant legs were tested using the same protocol. Verbal motivation was provided to all participants throughout the test (19, 20). The maximum torque values achieved by the participants were recorded in Newton meters (Nm) and included in the analysis.

Wingate Anaerobic Test (WAnT)

Participants' anaerobic power measurements were performed using a bicycle ergometer (Monark 894E, Sweden). First, during the preparation phase, the load to be used in the test was determined for each participant to correspond to 7.5% of their body weight, and the saddle height and sitting position were adjusted. Participants were asked to pedal at maximum effort for 30 seconds while seated during the test. Verbal motivation was provided to all participants throughout the test (21, 22). Participants' anaerobic power values were recorded in terms of absolute Peak Power (watts) and absolute Peak Power (watts/kg).

Change of Direction Speed (T-test)

Participants' change of direction speed performance was determined using the T-test, which is a suitable test for basketball. A marker was placed 0.5 m behind the photocell at the starting point to ensure that all participants started from the same point. Participants started the time by passing through photoelectric gates 1 m above the ground and 1.5 m apart, then ran straight to a cone 9 m away and touched it. Then, without crossing their feet and facing completely forward, they slid sideways to the other cone 4.5 m away and touched it. After touching the cone, they moved sideways toward the other cone 9 m away and touched it. Finally, they

came to the middle cone with the same sideways slides, touched the middle cone, and completed the test by running backwards to the starting point (Figure 2). The researcher monitored that the participants' bodies were completely facing forward during the sideways slides and backward runs and that the cones were touched correctly. All participants performed 2 trials, and the best time was recorded. A 1-minute rest period was provided between trials. Verbal motivation was provided during the test (23).

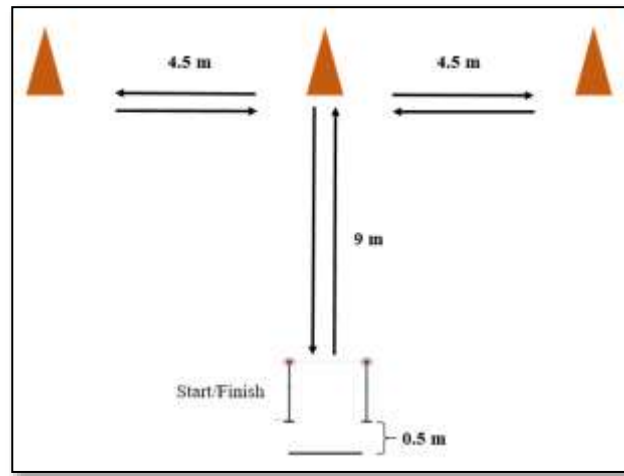


Figure 2. Change of Direction Test (CoDs, T test)

Ethical approval and institutional permission

Ethical committee approval was obtained from the Scientific Research and Publication Ethics Committee of Iğdır University before starting the research (Meeting date: 05.11.2025; Decision number: 2025/43).

Statistical Analysis

Statistical analysis was performed using the SPSS 27 software package. The normality of the data distribution was examined using the Shapiro-Wilk test. Descriptive statistics used arithmetic mean ($\bar{x}$) and standard deviation ($SD \pm$) values. The relationships between independent variables (lower extremity isokinetic strength, anaerobic power, change of direction speed) were examined using Pearson correlation analysis. In interpreting the R values, the following classification was used for correlation coefficients: >0.30 weak correlation, $0.3-0.6$ moderate correlation, $0.6-0.8$ strong correlation, and $0.8-1.0$ perfect correlation (24). Statistical significance was assessed as $p < 0.05$ and reported with a 95% confidence interval (95% CI). GraphPad Prism (10.6.1) software was used for graphing.

FINDINGS

Table 1. Descriptive anthropometric characteristics and performance variables		
Variables	N	Mean $\pm$ SD
Age (years)	29	15.48 $\pm$ 1.81
Weight (kg)	29	65.70 $\pm$ 12.48
Height (cm)	29	175.90 $\pm$ 7.50
Right Extension (N.m)	29	181.31 $\pm$ 24.16
Right Flexion (N.m)	29	98.48 $\pm$ 13.34
Left Extension (N.m)	29	168.56 $\pm$ 21.41
Left Flexion (N.m)	29	94.55 $\pm$ 14.47
PP (w)	29	580.29 $\pm$ 80.40
PP (w/kg)	29	9.12 $\pm$ 0.89
CoDs (sec)	29	11.02 $\pm$ 0.50

SD = Standart Deviation; N.m = Newton-meter; PP = Peak Power; w = watt; w/kg = watt/kg; CoDs = Change od Direction Speed

Table 1 presents the means of the participants' descriptive anthropometric characteristics and performance variables.

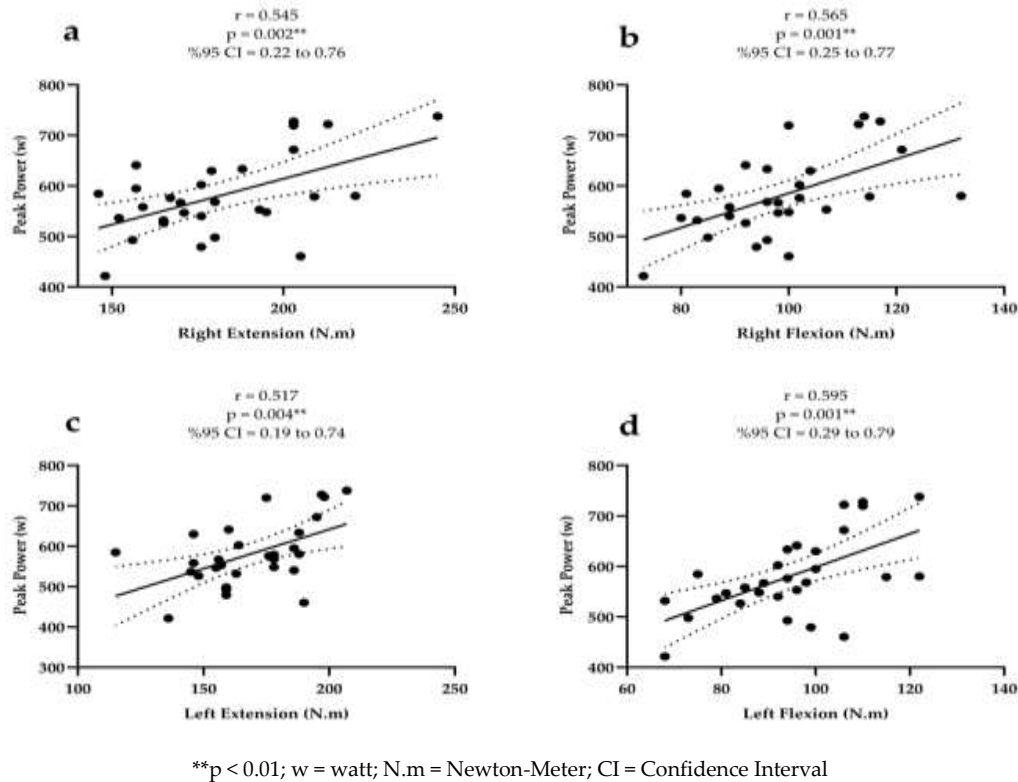


Figure 3. The relationship between isokinetic strength and absolute peak power (w).

A moderately significant positive correlation was found between the peak torque values of the participants' right knee extension ($r = 0.545$; $p = 0.002$; Figure 3a), right knee flexion ($r = 0.565$; $p = 0.001$; Figure 3b), left knee extension ($r = 0.517$; $p = 0.004$; Figure 3c) and left knee flexion ($r = 0.595$; $p = 0.001$; Figure 3d) and their absolute peak power (w) performance.

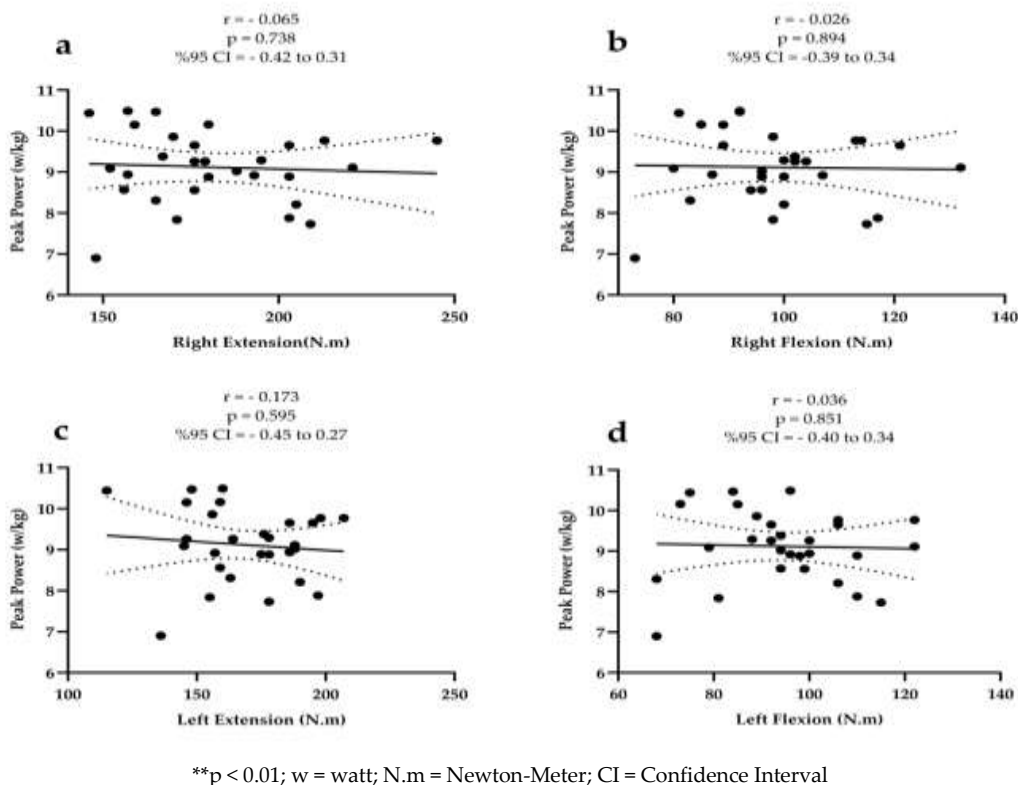
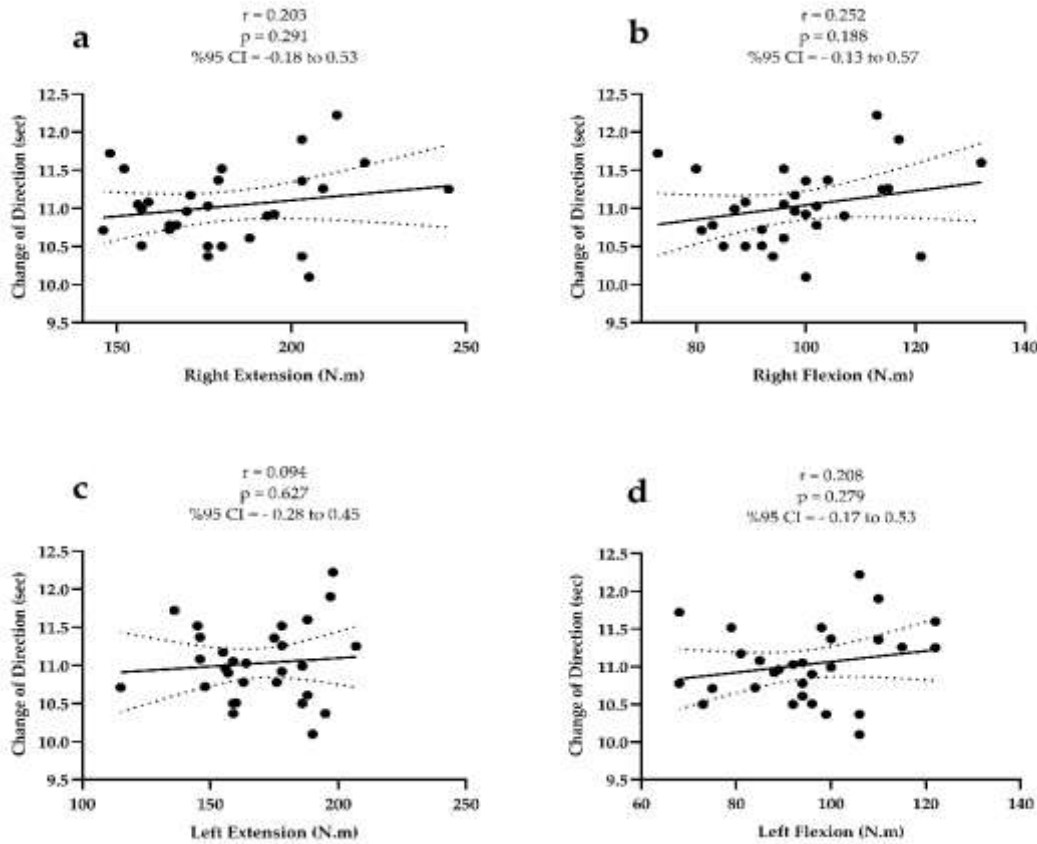


Figure 4. The relationship between isokinetic strength and relative peak power (w/kg).

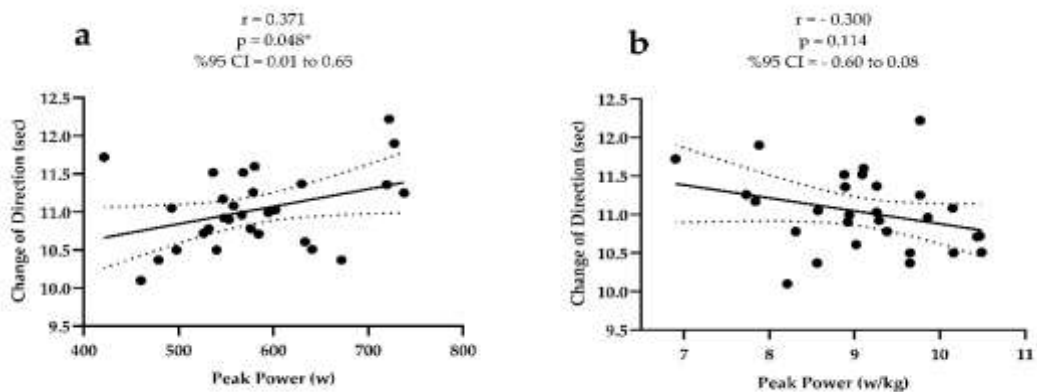
According to the Pearson correlation analysis results, no significant relationship was found between right and left knee extension and flexion peak torque values and relative peak power (w/kg) performance ($p > 0.05$; Figure 4a, b, c, d).



** $p < 0.01$; sec = seconds; N.m = Newton-Meter; CI = Confidence Interval

Figure 5. The relationship between isokinetic strength and change of direction speed (CoDs).

Pearson correlation analysis revealed no significant relationship between right and left knee extension and flexion peak torque values and change of direction speed ($p > 0.05$; Figure 5a, b, c, d).



* $p < 0.05$; w = watt; sec = seconds; CI = Confidence Interval

Figure 6. The relationship between change of direction speed (CoDs) and absolute peak power (w) and relative peak power (w/kg).

A moderate positive correlation was found between participants' change-of-direction speed and absolute peak power (W) ($r = 0.371$; $p = 0.048$; Figure 6a). No significant relationship was observed between change-of-direction speed performance and relative peak power (W/kg) values ($p > 0.05$; Figure 6b).

DISCUSSION AND CONCLUSION

This study aimed to determine the relationship between lower extremity isokinetic strength, anaerobic power, and change of direction speed in female basketball players. The main finding of the study conducted for this purpose was that there was a positive moderate correlation between lower extremity isokinetic strength (right and left knee extension and flexion) and absolute peak power (w) and between absolute peak power (w) and change of direction speed (CoDs) in female basketball players, but there was no significant relationship between relative peak power (w/kg) and lower extremity isokinetic strength and CoDs.

Studies examining the relationship between lower extremity strength and anaerobic power in the literature show findings that parallel those of this study. For example, Thorland et al. (25) found a significant and high-level relationship between lower extremity isokinetic strength and anaerobic power in female track and field athletes (sprinters and middle-distance runners). Similarly, Baker and Nance (26) found a high-level positive relationship between maximum strength and power performance in rugby players. In another study, Alemdaroğlu (13) determined that there was a significant relationship between quadriceps muscle strength and peak power in professional basketball players. Kin İşler et al. (11) and Atabek et al. (27) found a significant relationship between lower extremity isokinetic extension strength obtained at different angular velocities ($60^\circ/\text{s}$, $150^\circ/\text{s}$, and $240^\circ/\text{s}$; $60^\circ/\text{s}$, $120^\circ/\text{s}$, and $180^\circ/\text{s}$, respectively) and anaerobic power performance. Atabek (28) found a relationship between isokinetic strength and anaerobic power, consistent with our study findings. Soslu et al. (29) in basketball players, Yılmaz et al. (30) in soccer players, and Harbili (31) in athletes from three different sports (soccer, basketball, and weightlifting) determined that there is a relationship between lower extremity isokinetic strength and anaerobic power performance. Another study by Boraczyński et al. (18) also found a significant relationship between maximal strength and anaerobic power obtained with WAnT. However, despite this significant result, it was suggested that the WAnT test is more suitable for cyclists and that anaerobic power performance in different sports should be determined using different tests. Lee (32) also found a high correlation between the participants' isokinetic extension and flexion peak torque values and the peak power values obtained from the Wingate test in his study on female hockey players. He also stated that different angular velocities ($60^\circ/\text{s}$ and $180^\circ/\text{s}$) should be used when evaluating isokinetic parameters and that total work, as well as peak torque values, is important for power assessment. Studies have also shown that there is no relationship between lower extremity isokinetic strength values and relative anaerobic power, which supports our findings (28, 33, 30). On the other hand, there are studies that are inconsistent with our findings. Cometti et al. (34) and Newman et al. (35) stated that there is no relationship between lower extremity isokinetic extensor and flexor strength and anaerobic performance.

This study found no statistically significant relationship between lower extremity isokinetic strength and change of direction speed (CoDs). Studies supporting the findings of this study have been reported in the literature. Alemdaroğlu (13), Yapıcı (36), Aktug et al. (37), and Tatlıcioğlu et al. (16) reported no significant relationship between lower extremity isokinetic strength and change of direction speed in their studies conducted on athletes from different sports. Similarly, Yılmaz et al. (6), who investigated the relationship between lower extremity strength and change of direction performance in basketball players, and Yılmaz et al. (38), who investigated football players, found no relationship between isokinetic knee strength at $60^\circ/\text{s}$ angular velocity and change of direction speed. Furthermore, a review study by Sheppard and Young (39) emphasized that many studies have shown that concentric strength does not strongly predict change of direction speed performance. On the other hand, contrary to our findings, there are studies that suggest a significant relationship between lower extremity strength and change of direction speed. Nimphius et al. (40) and Peterson et al. (41) reported a strong relationship between lower extremity strength and change of direction speed performance in their studies on female softball players and female university student athletes from different sports, respectively. In another study, Kabacinski et al. (42) investigated the relationship between isokinetic leg strength and T-Test performance in professional soccer players and found only a moderate relationship between isokinetic knee flexion strength and change of direction speed. Papla et al. (2)

found that lower extremity strength was significantly related to change-of-direction performance in basketball players.

This study found a relationship between change-of-direction speed performance and absolute peak power, but no relationship between change-of-direction speed and relative peak power. Only a limited number of studies in the literature have examined the relationship between anaerobic performance and change-of-direction speed, and no study has specifically investigated the relationship between relative peak power and change-of-direction speed. Lockie et al. (43), in their study examining the relationship between two different change of direction (T-test and 505 test) performances and anaerobic power, did not find a relationship between anaerobic power and the T-test. In this respect, their findings do not support our study findings. However, Lockie et al. (43) found a high negative correlation between anaerobic power and the 505 test in the same study. This finding is parallel to our study findings and suggests that different change of direction tests may yield different results. In another study, Alvurdu et al. (44) stated that there was no relationship between the anaerobic power performance and change of direction abilities of futsal players. In his study on basketball players, Alemdaroğlu (13) found no relationship between peak power obtained with the WAnT test and change of direction performance. Furthermore, studies examining the relationship between change of direction and anaerobic performance have found statistically insignificant or very weak relationships.

The inconsistent results found in studies investigating lower extremity isokinetic strength, anaerobic power, and change of direction speed performance may stem from a variety of reasons. In particular, these inconsistencies may arise from differences in the characteristics of the participants included in the studies, such as their sport, training level, age, and gender. Additionally, the inconsistencies may stem from differences in the angular velocities used in the isokinetic strength tests preferred in the studies (60°/s, 120°/s, 150°/s, 180°/s, 240°/s, 600°/s, etc.) in the isokinetic strength tests preferred in the studies and the differences in the tests used to determine anaerobic power (Wingate test, jump tests, repeated sprint test, etc.) may also be the cause of these conflicting results. Furthermore, the use of tests involving open or closed kinetic chain movements (16, 42) and the predominant energy system requirements in the studies may also lead to conflicting results (13).

The current study may contribute to the field of sports science by resolving inconsistent results in the literature and providing information that coaches can use to improve and monitor athletes' performance. However, the study also has some limitations. Although the sample size was calculated and sufficient, the large sample size is a factor that could affect the results. The fact that only absolute strength was determined in the strength test, and relative strength was not determined, can be considered a shortcoming. Furthermore, the fact that only female athletes and players from a single basketball team were included in the study requires caution in interpreting the results. Another limitation of the study may be the use of non-functional tests such as isokinetic strength and WAnT, as well as a single change of direction test. Future studies planning their work with these limitations in mind may contribute to resolving conflicting results.

In conclusion, this study found that lower extremity isokinetic strength is an important parameter for predicting anaerobic power performance (absolute and relative peak power) but is not a good predictor of change of direction performance. It was also determined that absolute anaerobic power performance contributes to the improvement of change of direction performance.

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