Analele Universităţii din Oradea
Facicula Educaţie Fizică şi Sport
ISSN **2286-2870**, E-ISSN **1224-5100**

Rev. noXXXIV **/2024** pp. 3-11
Article no. **34101-883**

RELATIONSHIP BETWEEN CHANGE OF DIRECTION SPEED, LINEAR SPEED AND LOWER LIMB POWER OF YOUNG BASKETBALL MALE PLAYERS

Alexandru HUȚANU
Secondary School ''LPS Bihorul Oradea" Oradea, Calea Matei Basarb 4, 410095, Oradea, Romania, e-mail: hutanualexandru19@yahoo.com

Paul DRAGOȘ
University of Oradea, Department of Physical Education, Sport and Physical Therapy, Research Center for Human Performance, 1st University street, 410087, Oradea, Romania, e-mail: pdragos@uoradea.ro

Mirela ȘTEF*
University of Oradea, Department of Physical Education, Sport and Physical Therapy, Research Center for Human Performance, 1st University street, 410087, Oradea, Romania, e-mail: mstef@uoradea.ro

Dana CRISTEA
University of Oradea, Department of Physical Education, Sport and Physical Therapy, Research Center for Human Performance, 1st University street, 410087, Oradea, Romania, e-mail: dcristea@uoradea.ro

Melania KOKOVAY
CSM Oradea – Basketball Team, Oradea, Str. Traian Blajovici Nr. 24, 410209, e-mail: kokovaymelania@gmail.com

Marius MARINĂU
University of Oradea, Department of Physical Education, Sport and Physical Therapy, Research Center for Human Performance, 1st University street, 410087, Oradea, Romania, e-mail: mmarinau@uoradea.ro

Abstract: Purpose: The aims of this study was to identify the relationship between change of direction speed, jumping ability (lower limb power) and linear sprint performance in elite young (< 16 years) male basketball players. Method. A total of 149 basketball players, (mean age: 14.2±1.05, range 11–16), from four basketball clubs from the NW part of Romania, have participated in this study. To evaluate the performance in change of direction speed we used three tests (4x10m, 505m. and T test modified), for lower limb power we used also three tests (standing long jump, countermovement jumps and vertical reactive power) and for linear sprint speed we used 20 meters test. Results. It was found that a strong and moderate correlation among all the tests included in our research. For change of direction performance *(COD_505)*, the correlation was strong in relation to 20m in the U14 and U16 categories and moderated in relation to 20m in U12 category and to SLJ, CMJ f.a, VRP in all categories. For change of direction performance *(COD_4x10m_agility_shuttle)*, the correlation was strong in relation to 20m and CMJ f.a in all categories, with SLJ in U12, U16 and with VRP in U14 and moderated in relation to SLJ in U14 and with VRP in U12, U16 categories. For change of direction performance *(COD_T_test_20m._modified)*, the correlation was moderated in relation to 20m, SLJ, CMJ f.a, VRP in all categories. Conclusion. The change of direction

* Coresponding Author

performance is related to important physical capacities for young basketball players, such as linear sprints and lower limb power. Thus, the change of direction performance.

Key words: change of direction speed, lower limb power, linear speed, basketball

* * * * * *

INTRODUCTION

Movements in team sports often require athletes to produce force unilaterally in unpredictable and variable contexts with an emphasis on eccentric and multidirectional movement patterns (Tous-Fajardo et al., 2016). Basketball is no exception, just as Bektaș et al, 2007, affirmed that it is required reactive strenght and agility, in which all the basic biomotor characteristics need to be developed in a coordinated fashion (Bektaș et al., 2007). This developemnt plays an active role in improving and shaping biomotor properties. In basketball, which incorporates high-intensity activity, fast attacks and high jumps are crucial for a successful defense. Basketbal players must have well-developed agility and jumping skills in order to acchieve victory over the opponents; hence agility and jumping ability are of critical importance (Ari et al., 2017). The court time of a player during a match increases with the success of player's dribbling, passes and overall performance (Usgu, 2015).

One of the biomotor characteristics is strength, which constitutes one of the main determinants of success in sports. Strength is the ability to overcome resistance, in different forms applicable in different games (Nimphius et al., 2010). The reactive force index (RSI) is a tool of monitoring the stress on muscles and tendons (McClymont & Hore, 2003), determining height as measured by amplitude and incorporating the length of ground contact time.

Reactive strength has been "defined as the ability to change quickly from an eccentric to a concentric contraction" (Young, 1995) by taking advantage of the stretch-shortening cycle (SSC), which consists of quick eccentric–concentric muscular contractions (Lloyd et al., 2009). The use of RSI is vital for high-performance sports professionals, as it can be used as a motivational tool, in a way that coaches can instantly deliver feedback to their athletes, according to their RSI value, in order to improve their physical performance (Flanagan et al., 2008; Sandra et al., 2023).

Another biomotor characteristic that affects performance is agility, defined as the ability to move the body and change direction between two points with ease, speed and fluidity while employing balance, speed, strength and neuromuscular coordination in a controlled manner. (Turner, 2011) Twist & Benicky define agility as the ability to move and change direction and position the body quickly and effectively while under control (Twist & Benicky, 1996).

The actions during basketball game include variety of movements such as running, dribbling, shuffling, and jumping, which are directional, multidirectional, intense and short-lasting. Generally, there are a large number of sprints and jumps. Speed activities take an important part of athlete development in young basketball players. Time motion analysis during a basketball game showed that on average 1000 movements were performed by basketball players, with an average duration of shorter than 3 seconds (Abdelkerim et al., 2010).

Change-of-direction (COD) speed has been proposed to combine three factors: technique, straight-sprinting speed, and leg-muscle qualities (Young, 2002). COD refers to the reorientation and alteration in the path of travel of the entire body's center of mass toward a new intended direction. This action holds pivotal significance in achieving success in multidirectional sports (Izquierdo, 2023).

OBJECTIVES OF THE STUDY

The aims of this study were to identify the relationship between change of direction speed (4x10m, 505m. and T-test modified), jumping ability (countermovement jump, vertical reactive power and standing long jump) and sprint (20-m) performance in elite young (< 16 years) male basketball players.

MATERIALS AND METHODS

Participants

A total of 149 basketball players, (mean age: 14.2±1.05, range 11–16), from four basketball clubs from the NW part of Romania, have participated in this study. All the participants competed in the Romanian youth league, in their age category.

All players have been practicing regularly for 4-8 years (four to six days a week), and involved of combined basketball training and competitive play per week. The players were grouped based on chronological age categories: under 12 (U12 – 42 subjects), under 14 (U14 – 59 subjects) and under 16 (U16 – 48 subjects). At the beginning of the study, participant athletes were verbally informed about research protocols and written consents were obtained from the athletes prior to participation in the study. The study was conducted in accordance with the Declaration of Helsinki.

Table 1. Anthropometric characteristic of the study participants, U12, U14 and U16 basketball players

Variables	*U12 (n=42)*	*U14 (n=59)*	*U16 (n=48)*
	Mean±SD	*Mean±SD*	*Mean±SD*
Height (cm)	165,47 ± *6.53*	171.20 ± *9.67*	186.14 ± *6.99*
Weight (kg)	*49.27 ± 10.55*	55.93 ± *11.96*	*71.64 ± 9.12*
BMI (kg/m^2)	*17.85 ± 2,61*	19.07 ± *2,58*	*20.48 ± 1,48*

Procedures

All tests were carried out in two sessions, for each group, before the 2023/2024 competition season, after 6-8 weeks of preseason preparation. In the first testing session, after the anthropometric measurements, we tested lower limb power and linear running speed (20 meters). Agility and Change of Direction Performance (COD_4x10m, COD_505, COD_T_test_20m_mofidied), were performed on the second day. Before every test session, all players performed a 20-minute athletic warm-up supervised by a strength and conditioning coach. All tests were performed on hardwood floor.

The relationships between Change of Direction Performance and sprint and lower limb power were analyzed using the Pearson Correlation Analysis (*r*), with the level of statistical significance set at $p \leq 0.05$ in SPSS (SPSS for Windows, Inc. Version 22, Chicago, Illinois).

The term correlation is used in the context of a linear relationship between 2 continuous variables. The Pearson correlation coefficient is typically used for jointly normally distributed data. Correlation coefficients are scaled such that they range from –1 to +1, where 0 indicates that there is no relationship between the movement of the two variables, and -1 shows a perfect negative correlation, while a correlation of 1 shows a perfect positive correlation. Several approaches have been suggested to translate the correlation coefficient into descriptors like “weak”, “moderate” or “strong” relationship. According to Y. Chan (2003), C. Dancey (2007), C. Bailey (2021), P. Schober (2018), we can consider different cutoff points to interpret the size (strength) of a correlation coefficient: .9-1.00 (very strong), .7-.9 (strong), .5-.7 (moderate), .3-.5 (low), .0-.3 (negligibile).

Instruments and tests used

Anthropometric Data

The athletes' body heights were measured with a scale having a sensitivity of 0.01 meters (m), and their body weights (BW) were measured with with a sensitivity level of 0.1 kilograms (kg) (Seca 700 mechanical column scale with eye-level beam). The BMI was calculated by dividing subjects' weight in kilograms by their height in metres squared.

Change of Direction Performance (COD_505) - 505m. Test

The 505 test involves a 10-m sprint past a timing gate (Witty Gate system, MicroGate, Bolzano, Italy) a further 5-m sprint to a turning line where 1 leg needs to reach and plant at the line, before the athlete completes a 180^{0} turn and sprints back through tje timing gates. Each participant started from a standing position, the subjects performed two maximal attempts, only the best (the shortest) time was used in analysis.

Change of Direction Performance (COD_4x10m_agility_shuttle) - 4x10m. Test

The 4x10m. agility shuttle test is a simple running test of agility involving linear sprint and 180° turn, between two lines 10 meters apart, was a total of 40 meters is covered. The subject runs to the opposite line, one foot has to touch the ground beyond the line, then turns 180° back to the start/finish line to touch the ground again, turning to sprint back to the line 10 meters away and touch the ground, then sprint back crossing the start/finish line to complete the test. The best performance from two maximal attempts (by 2 minutes rest) was used in analysis.

Change of Direction Performance (COD_T_test_20m._modified) - (T-test modified)

The 20 m., T-Test is a simple running test of agility, involving forward, lateral, and backward movements. The subject starts from a standing position, with his front leg on the starting line. The start-line is positioned 0.3m behind the timing gate (Witty Gate system, Microgate, Bolzano, Italy). The subject sprints forward (5 m) to a cone and touches the top of the cone with their right hand. They then turn 90° left and shuffle (2.5 m) sideways to the next cone, and also touches its top, this time with their left hand. Then shuffling (5 m) sideways to the right to another cone and touching the top with the right hand. They then shuffle (2.5 m) back to first cone touching with the left hand and run backwards (5 m) to starting line. The best performance from two maximal attempts (by 2 minutes rest) was used in analysis. The subject was not allowed to cross one foot in front of the other while shuffling, and to touch the top of the cones was a mandatory request.

Sprint Test 20 meters (20m)

Before the test, the basketball players performed a specific warm-up involving two sprints with maximal intensity on 10-15m. The sprint times were recorded by double photocells (Witty Gate system, Microgate, Bolzano, Italy) positioned at the starting spot (the start-line is positioned 0.5m behind the first timing gate) and finishing lines (20 m) at a height of 0.7 m. The subjects performed two maximal attempts for the 20 m distances. Only the best (the shortest) time was used in the subsequent analysis. Each participant started from a standing position, with his front leg on the starting line. The resting periods were 240 s after each 20 m sprint.

Explosive horizontal power of the lower limb - Standing Long Jump Test (SLJ)

Each subject performed the horizontal long jump starting from a standing position. They commenced the jump by swinging their arms and bending their knees to provide maximal forward drive. A take-offline was drawn on the ground, positioned immediately adjacent to a jump sandbox. The jump-length measurement was determined using a metallic metric tape measure, from the nearest point of landing contact (i.e., back of the heels) to the take-offline. Each athlete executed two attempts and the best performance (longest distance) was considered.

Explosive vertical power of the lower limb - Countermovement jump (CMJ)

Before the test, the basketball plyers performed a specific warm-up involving five vertical jumps. Using an optical measurement system consisting of a transmitting and receiving bar (Optojump next, Microgate Engineering, Bolzano, Italy) the test comprised two maximal vertical jumps with swing arms (Counter Movement free arms Jump). The resting period between jumps was two minutes. Only the best (the highest) jump was used in the subsequent analysis.

Vertical reactive power of the lower limb - Optojump stiffness free arms test (VRP)

Then, after a 5-minute break, the athletes made Optojump stiffness free arms test (OST), 7 possibly highest jumps with straight knees, one after another without a rest break. The maximal vertical power (W/kg.) performance (VRP) of the 7 jumps (VRP avg. power) was calculated for performance analysis. The athletes were instructed to jump as high as possible while minimizing ground contact time. This test was performed by each athlete twice with 120 seconds of rest between trials and the best performance was recorded.

RESULTS AND DISCUSSION

Results

All data presented normal distribution. Table 2 shows the descriptive data (mean and standardized mean differences) for each one of three groups of subjects (U12, U14 and U16). In all the tests applied, higher value performances can be observed as the age categories increase, an observation that can be explained by the fact that with age the motor qualities of the subjects reach higher indices of expression, here adding personal experience.

Table 2. Physical performance indicators in young basketballers in the groups U12, U14 and U16

Variables	*U12 (n=42)*	*U14 (n=59)*	*U16 (n=48)*
	Mean±SD	Mean±SD	Mean±SD
20 m. (s.)	3.77±0.21	3.49±0.21	3.24±0.15
4x10 m. (s.)	10.46±0.37	9.85±0.42	9.29±0.33
505 m. (s.)	2.61±0.20	2.46±0.12	2.33±0.11
T-test modif. (s.)	6.44±0.30	6.05±0.23	5.68±0.22
SLJ (m.)	1.82±0.13	2.02±0.18	2.25±0.15
CMJ.f.a. (cm.)	33.99±4.24	38.22±3.89	43.07±4.14
VRP (W/kg.)	42.7 ±4.51	47.7 ±3.46	53.0 ±4.00

Relationship between Change of Direction Performance (COD_4x10m_agility_shuttle) and linear sprint speed and lower limb power**.**

Table 3. Pearson correlation coefficients (r) of the b *between 4x10 meters and* physical performance in speed and explosive strength

Variables	*U12 (n=42)*	*U14 (n=59)*	*U16 (n=48)*
20 m. (s.)	0.78	0.83	0.87
SLJ (m.)	-0.80	-0.71	-0.75
CMJ.f.a. (cm.)	-0.77	-0.77	-0.79
VRP (W/kg.)	-0.74	-0.78	-0.67

According to Table 3, we can observe a strong correlation between 4x10m agility shuttle and 20m ($r > 0.75$) in all age categories. However Little T. et.al (2005) reported a weak correlation between 10m sprint and zig-zag agilty test ($r = 0.346$) same between fly 20m test and zig-zag agility test ($r = 0.458$), the large discrepancy between the studies can be attributed to the different agility tests performed.

Strong negative correlations exist between 4x10m and CMJ.f.a in all age categories U12 (r= -0.77), U14 (r= -0.77) and U16 (r= -0.79). The same is the relationship with SLJ in the categories U12 (r= -0.80) and U16 (r= -0.75), only in the case of the category U14 a moderate correlation is recorded (r= -0.71). Also, Köklü, Yusuf et. al (2014) notice a moderate negative correlation between the zig-zag agility test without a ball and CMJ (r= -0.769)

A strong correlation with VRP is registered only in the case of the U14 category (r= -0.78) and moderate in the U16 (r= -0.67) and U12 categories (r= -0.74)

Relationship between Change of Direction Performance (COD_505) and linear sprint speed and lower limb power

Table 4. *Correlation between 505 meters and* physical performance in speed and explosive strength

Variables	*U12 (n=42)*	*U14 (n=59)*	*U16 (n=48)*
20 m. (s.)	0.74	0.79	0.75
SLJ (m.)	-0.74	-0.61	-0.61
CMJ.f.a. (cm.)	-0.68	-0.66	-0.64
VRP (W/kg.)	-0.69	-0.64	-0.63

In the case of the relationship between 505 and linear speed, the correlations are strong, less so at U12 (r= 0.74) where it is moderate. Delaney et al., (2015) correlates 505 tests on the dominant leg with maximal sprint velocity 30–40 m [s] obtaining a moderate coefficient (r= -0.63). Also, a moderate correlation between 505 agility test and 10m sprint in girls from the 2nd division (r= 0.55) was also observed by Lockie et.al (2018).

Moderate negative correlations are also found between 505 and SLJ, CMJ f.a and VRP, the lowest being recorded in the case of SLJ in the U16 category (r= -0.61) and the highest also in relation to SLJ only as in the U12 category (r= -0.74). Thomas. C et.al (2017) detects a moderate correlation between CMJ and 505 agility test on the right leg (r= -0.60) and on the left leg (r= -0.71). Musab Çağin et.al (2024) also observe a moderate negative correlation between 505 test (10m) and CMJ (r= -0.71). Contrary to our results Kahraman et.al (2023) report a weak correlation between RSI (11 jumps were conducted for the RSI measurement, the first jump being excluded from the assessment) and 505 agility test (r= -0.459)

Relationship between Change of Direction Performance (COD_T_test_20m._modified) and linear sprint speed and lower limb power

Table 5. *Correlation between T-test modified and* physical performance in speed and explosive strength

Variables	*U12 (n=42)*	*U14 (n=59)*	*U16 (n=48)*
20 m. (s.)	0.67	0.70	0.68
SLJ (m.)	-0.69	-0.57	-0.62
CMJ.f.a. (cm.)	-0.72	-0.70	-0.61
VRP (W/kg.)	-0.71	-0.73	-0.52

According to table 5, we find moderate correlations between T-test and 20m, the highest being in the U14 category (r=0.70). Similar to us Abbas Asadi et.al (2016) reports a strong correlation between T-test and 20m sprint (r= 0.77).

In the relationships between T-test and explosive strength tests, moderate negative correlations are found, the most significant being U12 SLJ (r= -0.69), CMJ f.a (r= -0.72) and U14 VRP (r= -0.73), the lowest value of correlations can be seen in the relationship between T-test and

VRP in the U16 category (r= -0.52). Utku Alemdaroğlu et al., (2012) observes a moderate correlation between T-test and CMJ (r= -0.594). Also, Isaiah T. McFarland et.al (2016) report a strong negative correlation coefficient between T-test and CMJ (r=-076) in the case of female players but weak in the case of male players (r= -0.16).

CONCLUSIONS

In conclusion, the findings of this study demonstrate that there is a moderate to high correlation between the ability to change direction in speed and the explosive power of the lower limbs in young male basketball players. This may be due to the fact that the tests used in this study basically use the same energy system and are performed through a strong and fast muscle contraction. So this suggests that change of direction and explosive power of the lower limbs are determined by the same physiological and biomechanical factors.

However, the correlation coefficient values revealed between the modified T-test and power of the lower limbs are lower than those obtained between the other two tests measuring change of direction speed (4x10m and 505m) in relation to lower limb power. We believe that this is a consequence of the fact that in this test the movement technique (which includes, in addition to changes of direction and accelerated forward running, lateral movements and backward running), the degree of its acquisition, could influence in some measure of performance obtained.

Tables 2, 3, and 4 highlight the fact that in the U16 age category, the correlation coefficients between the change of direction speed tests and lower limb power and linear speed are lower than those obtained in the U12 and U14 age categories. We believe this is due to the changes caused by the developmental stage of the U16 group, which is also evidenced by the weight difference compared to the U14 age category (+28.09%), compared to the weight difference between the U14 and U12 categories (+13.52%). This seems to be reflected in the results obtained in the change of direction tests.

A clear limitation of this study arose, namely, in the population studied. Future studies should focus and on other collective sports disciplines (football, handball, voleyball), as well as on other age categories and differentiated by gender.

REFERENCES

Abdelkerim, N. B., Castagna, C., Jabri, I., Battikh, T., El Fazaa, S., & El Ati, J. (2010). "Activity profile and physiological requirements of junior elite basketball player in relation to aerobic-anaerobic fitness". *Journal OfStrength and Conditioning Research*, 24(9), 2330–2342.

Alemdaroğlu, Utku. (2012). "The Relationship Between Muscle Strength, Anaerobic Performance, Agility, Sprint Ability and Vertical Jump Performance in Professional Basketball Players". *Journal of human kinetics*. 31. 149-58.

Arı, E., Çakmak, E., Nefesoğlu, İ. C., Karatopak, T., Özden, A., Gürbüz, C. ve Özsoy, G. (2017). "Genç futbolcu ve basketbolcuların farklı çeviklik testleri açısından değerlendirilmesi." "Evaluation of young football players and basketball players in terms of different agility tests." *Uluslararası Anadolu Spor Bilimleri Dergisi*, 2(3), 216-226.

Asadi, Abbas. (2016). "Relationship Between Jumping Ability, Agility and Sprint Performance of Elite Young Basketball Players: A Field-Test Approach". *Brazilian Journal of Kinanthropometry and Human Performance*. 18.

Bektaş, Y., Özer, B. K., Gültekin, T., Sağır, M., & Akın, G. (2007). "Bayan basketbolcuların antropometrik özellikleri: Somatotip ve vücut bileşimi değerleri." "Anthropometric characteristics of female basketball players: Somatotype and body composition values." *Beden Eğitimi ve Spor Bilimleri Dergisi*, 1(2), 52-62.

Chan Y.H. (2003). "Biostatistics 104: correlational analysis." *Singap. Med J.*; 44(12):614–619

Chris Bailey (2021). "Quantitative Analysis in Exercise and Sport Science". *University of North Texas Libraries*

Çağın, M., Doğan, B., Çimen Polat, S., Orhan, Ö., Sarol, H., & Çağlar, E. Ç., (2024). "Investigation Of The Relationship Between Reactive Strength And Speed, Change Of Direction, Agility And Reaction Time In Rugby Players". *Educational Administration: Theory and Practice,* vol.30, no.4, 141-151.

Dancey C.P., Reidy J. (2007). "Pearson Education. Statistics without Maths for Psychology"

Delaney, Jace & Scott, Tannath & Ballard, David & Duthie, Grant & Hickmans, Jeremy & Lockie, Robert & Dascombe, Ben. (2015). "Contributing Factors to Change-of-Direction Ability in Professional Rugby League Players." *Journal of strength and conditioning research / National Strength & Conditioning Association*. Publish Ahead of Print.

Flanagan, E.P.; Comyns, T.M. (2008). "The Use of Contact Time and the Reactive Strength Index to Optimize Fast Stretch-Shortening Cycle Training". *Strength Cond. J.* 30, 32–38.

Horníková, Henrieta, and Erika Zemková. (2021). "Relationship between Physical Factors and Change of Direction Speed in Team Sports." *Applied Sciences* 11, no. 2: 655.

Izquierdo Velasco, José. (2023). "Why is Change-of-Direction Speed in Team Sports Important? " *Training and Evaluation*.

Kahraman, Muhammed & Özkan, Zekiye. (2023). "The Relationship Between Reactive Strength Index and Agility in Young Male Volleyball and Basketball Players". *Yalova Üniversitesi Spor Bilimleri Dergisi*. 100-112.

Köklü, Yusuf & Alemdaroğlu, Utku & Özkan, Ali & Koz, Mitat & Ersoz, Gulfem. (2014). "The relationship between sprint ability, agility and vertical jump performance in young soccer players." *Science & Sports*. 30.

Little, Thomas & Williams, Alun. (2005). "Specificity of Acceleration, Maximum Speed, and Agility in Professional Soccer Players". *Journal of strength and conditioning research / National Strength & Conditioning Association*. 19.

McClymont, D., & Hore, A. (2003). "Use of the reactive strength index (RSI) as an indicator of plyometric training conditions. In Science and Football" *V: The proceedings of the fifth World Congress on Sports Science and Football*, Lisbon, Portugal (Vol. 408, p. 16).

Mcfarland, Isaiah & Dawes, Jay & Elder, Craig & Lockie, Robert. (2016). "Relationship of Two Vertical Jumping Tests to Sprint and Change of Direction Speed among Male and Female Collegiate Soccer Players". *Sport*. 4.

Mihai Șandra, Dragoş Vasile Săvescu, Gheorghe Codruț Bulz, Marius Alin Marinău. (2023). "Development of speed and strength in young football players aged 10-12 years". *Analele Universităţii din Oradea. Fascicula Educaţie Fizică şi Sport*, 3-12

Nimphius, Sophia, Mcguigan, Michael R, Newton, Robert U. (2010). "Relationship Between Strength, Power, Speed, and Change of Direction Performance of Female Softball Players."*Journal of Strength & Conditioning Research*. 24(4):885-895.

Reactive Strength Index in Youths. J. Sports Sci. 2009,27, 1565–1573.

Schober P, Boer C, Schwarte LA. (2018). "Correlation Coefficients: Appropriate Use and Interpretation". *Anesth Analg.*;126(5):1763-1768.

Thomas, Christopher & Comfort, Paul & Jones, Paul & Dos'Santos, Thomas. (2017). "A Comparison of Isometric Mid-Thigh Pull Strength, Vertical Jump, Sprint Speed, and

Change of Direction Speed in Academy Netball Players". *International Journal of Sports Physiology and Performance*. 12. 1-20.

Tous-Fajardo, J.; Gonzalo-Skok, O.; Arjol-Serrano, J.L.; Tesch, P. (2016). "Enhancing Change-of-Direction Speed in Soccer Players by Functional Inertial Eccentric Overload and Vibration Training. " *Int. J. Sports Physiol*. Perform. 11, 66–73

Turner, A. (2011). "Defining, developing and measuring agility" *Prof Strength Cond*, 22, 26-28.

Twist, P. W., & Benicky, D. (1996). "Conditioning lateral movements for multi-sport athletes: Practical strength and quickness drills." *Strength and Conditioning*, 18(5), 10-19.

Usgu, S. (2015). "Profesyonel basketbol oyuncularında fonksiyonel eğitimin performansla ilişkili fiziksel uygunluk parametrelerine etkisi [Yayınlanmamış yüksek lisans tezi] ". *Hacettepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Ankara*.

Young WB, James R, Montgomery I. (2022). "Is muscle power related to running speed with changes of direction? " *J Sports Med Physical Fitness* 42(3): 282- 288.

Young WB. (1995). "Laboratory strength assessment of athletes". *New Studies Athletics* 10(1): 88-96.

Submitted:	Revised:	Accepted and published online
July 23, 2024	August 21, 2024	September 11, 2024