Chapter 7

The Relationships Between Hop and Return Test, Linear Sprint and Change of Direction Sprint Performance

Çağlar Edis[1]

Aysu Velimahmutoğlu[2]

Abstract

Numerous studies in the literature have examined the relationship between athletes' strength levels and their speed and change-of-direction running skills. However, no study has been found that examines the relationship between the hop and return strength test, which requires jumping and turning, and speed and change-of-direction running skills. The aim of this study was to examine the relationship between hop and return test (changing direction to the right and left with one leg) with speed and direction-changing runs. A total of 47 male football players who train regularly participated in the study (Age (years): 15.38±1.294, height (cm): 171.73±9.150, weight (kg): 64.52±11.046, Bmi: 21,64±2,121). The athletes' hop and return strength test was performed using a force platform. For the speed test, a 20-m linear sprint was used, and for the change-of-direction running test, the Illinois agility test was applied. In the analysis of the obtained data, the Shapiro-Wilk test revealed that the data did not fit a normal distribution, and Spearman's rank correlation coefficient analyses were used for the correlation analysis. While negative correlations were obtained between athletes' peak take-off and peak landing forces (n) and change-of-direction running and 20-m sprint tests (r values between -0.403** and -0.663**), positive correlations were found between concentric and eccentric muscle contraction times (ms) and 20-m sprint and Illinois agility times (r values between 0.318* and 0.520**). The findings revealed that athletes' hop and return strength levels are related to their 20-m sprint and agility skills, and

1 Dr. Ögr. Üyesi, Trabzon Üniversitesi, Spor Bilimleri Fakültesi, Trabzon/Türkiye
caglaredis@trabzon.edu.tr, Orcid: 0000-0001-7784-367X

2 Trabzon Üniversitesi, Spor Bilimleri Fakültesi, Trabzon/Türkiye
aysu_velimahmutoglu23@trabzon.edu.tr, Orcid: 0009-0000-4599-2312

https://doi.org/10.58830/ozgur.pub982.c4027

that this testing method can provide important information for evaluating athletes' performance. Coaches' preference for hop and return strength tests, such as vertical jump tests, can provide important information for evaluating athletes' performance.

INTRODUCTION

Although a football match is predominantly played using the aerobic energy system, one-third of the effort displayed during the match occurs at speeds of 14 km/h and above (Bradley et al., 2009). At such high speeds, footballers frequently perform sprints, jumps, positive and negative acceleration, and change-of-direction runs at short intervals (Stojanović et al., 2018). The ability to change-of-direction running plays a significant role in team sports. When performing change-of-direction runs, athletes accelerate and decelerate with high intensity and make sudden change-of-direction (Little & Williams, 2005). These complex change-of-direction runs are performed through the coordinated action of skills such as muscle and core strength and balance (Sekulic et al., 2013; Savla et al., 2020). Therefore, jump tests can be important in predicting the change of direction running skills of athletes or in determining the situation for them to be more successful (Castillo-Rodríguez et al., 2012). At this point, many studies examining the change of direction running and strength levels of athletes have been applied and it has been reported that there are correlations between different jump or strength tests and the change of direction running skills of athletes (Castillo-Rodríguez et al., 2012; Barnes et al., 2007; Meylan et al., 2009).

In football, athletes' speed skills are as important a physical fitness level as change-of-direction running (Gravina et al., 2008; Atıcı & Bayrakdar, 2025). Speed applications in a football match are performed approximately every 90 seconds and last between 2 and 4 seconds (Reilly, 1976; Bangsbo et al., 2006). The strength level of athletes is also crucial for the optimal application of speed skills (Cronin & Hansen, 2005; McBride et al., 2009; Wisløff et al., 2004). Strength, anaerobic power, and particularly lower extremity strength levels are also highlighted in the literature as being important for speed-demanding activities (Bimson et al., 2017; Meckel et al., 2018). Research in the literature has examined the relationship between strength and speed, focusing on how strength levels may be influenced by or influence speed ability (Atıcı & Bayrakdar, 2025). While some studies indicate strong relationships between squat strength and speed ability (McBride et al., 2009; Wisløff et al., 2004), other studies show weak or no relationship between strength level and speed ability (Harris et al., 2008). It is evident that correlation relationships in studies vary depending on the tests and methods applied, and that the relationships between speed or change-of-direction running skills and strength parameters are low, moderate, or high correlations.

As can be understood from the literature, while there are studies examining the relationship between muscle strength and change-of-direction running and speed, no study has been found that specifically examines the relationship between speed and change-of-direction running in relation to the skill of performing a lateral jump and then jumping back to the initial position simultaneously on one leg, particularly in a non-vertical manner. At this point, the aim of this study was to examine the relationship between hop and return test (changing direction to the right and left with one leg) with speed and direction-changing runs.

METHOD

Participants

A total of 47 volunteers who regularly train 5 times a week and play amateur football participated in the study (Age (years): 15.38±1.294, height (cm): 171.73±9.150, weight (kg): 64.52±11.046, Bmi: 21,64±2,121). Before the research commenced, the necessary ethical committee approvals were obtained from the Trabzon University, Health Sciences Non-Interventional Research Ethics Committee, on 18 September 2025 with document number E-71551547-050.04-2500054723. Prior to the start of the research, the subjects were informed about all the details of the research, and athletes were included in the research in accordance with the Declaration of Helsinki.

Data collection tools: Anthropometric measurements

For the height measurements of the athletes, measurements were taken from the ground to the top of the head with the help of a simple tape measure. The data obtained were recorded in cm. The weight measurements of the athletes were measured with the help of a digital scale by stepping on the scale barefoot with only shorts on. The body weight obtained was recorded in kilograms.

Hop and Return Test

Jumping and return jumping skills of the athletes were performed with the VALD Performance Forceecks (ForceDecks, FDLite V.2, VALD, Brisbane, Australia) device. FIFA 11+ warm-up procedure was applied to ensure that the athletes could warm up well before the test (Bizzini et al., 2013). After the warm-up phase, the athletes were given a demonstration of how to stand and jump on the test equipment. Before the test of each athlete, the device was calibrated as indicated by the manufacturer (https://support.vald.com/hc/en-au/articles/17160684077977-ForceDecks-User-Guide). After calibration, the athletes stood on the device with both legs and waited motionlessly for the device to measure weight precisely. After the ready command was obtained, the athlete stood on one leg. The athlete then performed the single-leg measurement by jumping quickly from right to left and back to right on one leg (right leg example). The same procedure was then applied to the left leg. From the data provided by the device, the initial reaction was recorded as Peak Take-off Force [N], the muscle contraction initiating the jump was recorded as Concentric Duration [ms], the muscle contraction occurring while landing on the other platform was recorded as Eccentric Duration [ms], and the force applied at the moment of contact with the ground was recorded as Peak Initial Landing Force [N], and the time it took to stabilise as Time to Stabilisation [s].

Illinois Agility Test

The athletes' change-of-direction running tests were conducted using the Illinois agility test. The test course was constructed according to the measurements and dimensions specified in the literature (Raya et al., 2013). The athletes' movements involving acceleration, braking and sudden changes of direction (slalom) were tested in this test. The tests were conducted using equipment with infrared sensors positioned at a height of 1 metre at the start and finish points of the test course (Newtest Oy, Oulu, Finland, Power timer 300-series). To ensure that each athlete's measurement was standardised, a marker was placed 1 metre in front of the starting point of the test course, and athletes were asked to begin the test by starting from this point. To ensure that the test was performed with maximum effort by the athletes, each athlete was provided with verbal motivation in a strong voice from outside. The test was performed a total of three times, with a three-minute rest interval between each repetition, and the athletes' best scores were included in the statistical analysis.

20-m sprint test

The sprint test was conducted by setting up a simple track for the athletes. The test equipment (Newtest Oy, Oulu, Finland, Power timer 300-series) was positioned at the start and finish points of the 20-metre area at a height of 1 metre to create the test track. To standardise the acceleration performance of athletes at the starting point, a marker was placed 1 metre in front of the starting gate, and athletes were asked to align themselves with this marker before starting the test. Athletes were continuously motivated with loud encouragement throughout the test course. The test was administered to the athletes a total of three times, with a three-minute rest period between each administration. The athletes' best times were included in the statistical analysis.

Statistical analysis

The level of conformity of all data obtained for the research to normal distribution was tested by Shapiro Wilk Test. It was determined that the data did not conform to normal distribution in normality analysis and Spearmen rank correlation coefficient analyses were used for correlation analyses of the data. Additionally, the data obtained were presented as mean ± standard deviation and expressed as X ± Ss. The relationships between the athletes' hop and return strength test results and their speed and Illinois agility test results showed that as jump performance increased, they had shorter speed and agility application times, indicating a negative correlation. Positive statistical results, on the other hand, were interpreted as indicating no meaningful relationship between the performance tests.

FINDINGS

Table 1. Descriptive statistics of anthropometric characteristics of the athletes.

	n	Min.	Max.	Ortalama±Ss
Age (years)	47	14,00	17,00	15,38±1,294
Height (centimetres)	47	155,10	191,00	171,73±9,150
Weight (kg)	47	41,50	84,90	64,52±11,046
Bmi (kg.m^{-2})	47	16,80	26,70	21,64±2,121

Bmi: body mass index

Table 1 shows the minimum, maximum, mean and standard deviation values of the anthropometric characteristics of the athletes. In the performance test data not included in the table, the mean time of Illinois agility test was 15.78±657.466 seconds, while the mean time of sprint was 2.982±310.295 seconds.

Table 2. Relationships between hop and return strength test and sprint and agility test.

		Peak Take-off Force [N]		Concentric Duration [ms]		Eccentric Duration [ms]		Peak First Landing Force [N]		Time to Stabilisation [s]	
		Db	Ndm	Db	Ndm	Db	Ndm	Db	Ndm	Db	Ndm
İllinois Agility (second)	r	-,430**	-,403**	,318*	,467**	,454**	,409**	-,528**	-,542**	,175	-,018
	p	,003	,005	,030	,001	,001	,004	,000	,000	,262	,907
	n	47	47	47	47	47	47	47	47	43	43
20 m Sprint (second)	r	-,605**	-,600**	,367*	,520**	,417**	,480**	-,640**	-,663**	,163	-,039
	p	,000	,000	,011	,000	,004	,001	,000	,000	,298	,803
	n	47	47	47	47	47	47	47	47	43	43

$p<0.05$* Db: Dominant leg, Ndm: non-dominant leg

Table 2 shows the results of the statistical correlation analysis between the athletes' hop and return strength test and their sprint and agility times. Statistical significance was found in all data except for the Illinois and sprint test times and the stabilisation results ($p = 0.01$). The significant relationship between athletes' initial reaction time and the peak descent force (N) they applied during the second contact, and their speed and agility skills, revealed that as the force applied by the athletes increased, they completed the test in shorter times in terms of sprint and agility skill durations. Furthermore, it was found that as the concentric and eccentric muscle contraction (ms) times increased, the athletes completed the speed and agility skill tests in longer periods of time.

DISCUSSION AND CONCLUSION

This study examined the relationship between hop and return strength and sprinting and agility skills, which are applied differently from the jump tests and sprinting and agility skill tests in the literature. The research results revealed correlations between athletes' single-leg jump tests and their speed and change-of-direction running skills (r values ranging from 318* to 663**).

The relationship between athletes' sprinting and agility skills and their balance, strength and jumping skills has been frequently researched in the literature. When examining the relationship between athletes' leg muscle strength levels and their agility skills, numerous studies can be found. Markovic (Marcovic, 2007), in a study, examined the relationship between leg muscle strength and agility skills in 76 male students receiving physical education. The study found that correlations between athletes' leg muscle strength and explosive strength characteristics and three different agility skills were low. In a different study, no relationship was found between five different change-of-direction skills and squat jump power in 31 male athletes aged 20.02±1.89 from different sports. In addition, it was found that there was a correlation between strength and agility skills in female athletes, but no correlation was found in male athletes (Sekulic et al., 2013). The relationships between 60◦/s, 180◦/s and 300◦/s leg flexor and extensor muscle strength and squat and countermovement jump, 30 m sprint and T-agility were investigated in 21 professional level athletes aged 24.5±3.9 years. As a result of the correlation analyses performed in the study, it was reported that -0.473* correlation was found between squat jump heights and 30 m sprint, while moderate correlations were obtained between 60◦/s and 300◦/s isokinetic dynamometer data and T-agility times (Kabacinski et al., 2022). In a study conducted on 95 male football players, it was found that there was a correlation between the jumping performances of athletes with an average age of 12.27 ± 0.91 years and Illinois agility skills (r values between -0.47 and -0.80) (Negra et al., 2017). There are many similar studies in the literature, and it is seen that there are results with low, medium or no correlation with the leg muscle strength of athletes (Peterson et al., 2006; Young et al., 1996). However, it is seen that the relationships between single leg jumping skills and sprint and change of direction running skills of athletes have higher correlations. Pamuk et al. (2023) conducted a study examining the relationships between single leg jumping and speed and agility, stating that the relationship between single leg jumping skills and performance is still not fully explored. In the study, a total of 32 male basketball athletes aged 15.06 ± 2.62 years were subjected to single leg jump, sprint and agility measurements. In the study, it was found that there were moderate and high correlations between dominant and non-dominant leg jump data and speed and agility skills of athletes. In a different study, it was found that 39 male football players aged 15.19±3.15 years had low and moderate correlations between single leg jump performances and speed and agility skills. However, in the study, it was observed that jump performances were measured with the Opto Jump Microgate device with infrared instead of the force platform (Yanci et al., 2014). In the above two different studies that applied the single leg performance test, Pamuk et al. (Pamuk et al., 2023) performed the measurements using a force platform as in this study. In this study, correlations were found between the results of the single leg jump test performed on the strength platform and agility and 20 m sprint skills (table 2). Unlike the literature, in this study, single leg medial jump data did not show any correlation between the time between the athletes suddenly jumping to the other platform with one leg while on the left or right platform and returning back to the other platform and their sprint and change of direction running skills. However, the correlation relationship between the first reaction time (first reaction time in single leg lateral jump), the concentric muscle force for heading upward and medial direction and the eccentric muscle force for braking while falling to the side platform and the peak landing force with speed and agility was found at medium and high values. This study shows similar results to those of Pamuk et al. (2023), while also showing results similar to those of Yanci et al. (2014), but with higher correlations. The most fundamental reason for this situation is thought to be the use of a different test for jumping ability in this study, namely the single-leg directional change jump performance, and the equipment used. In addition, the relationship between athletes' peak take-off force and landing force is negative. This correlation has statistically demonstrated that athletes apply force with greater sprint and agility in a shorter time. Furthermore, the longer concentric and eccentric muscle contraction times in athletes' jump tests have revealed statistical results indicating that they possess poorer speed and agility skills. This information obtained in the study adds new information to the literature specific to the test applied. It is stated that eccentric muscle contraction helps athletes to change direction faster, especially at the breaking point in agility skill (Jones et al., 2009). In this study, the result that athletes apply speed and agility skills in a longer time with the increase in eccentric muscle contraction times is in parallel with the literature. Similarly, the maximum muscle force that athletes apply vertically to the ground is very important for speed applications on the field. Because it is the first starting point of the movement and this force production that occurs with concentric muscle contraction reveals the quality of speed production (Pereira et al., 2018). In this study, it was found that athletes had worse speed and agility skills as the concentric muscle contraction time increased. This situation suggests that the increase in the speed production time of the athletes to take action may be due to the negative effect on their reaction times.

This research has some limitations. Although it reveals the relationship between a new test data (jump and turning strength) and speed and agility skills, the interpretation of the obtained data and its reflection in the discussion section constitute the limitation of the research. In addition, the application of the research only on male football players between the ages of 14-17 may mean that generalisations cannot be made for different branches. At this point, the test data used in this study and the use of only football players in the tests constitute the limitation of the research.

References

Atıcı, M., & Bayrakdar, A. (2025). The Effects of TRX-Based Functional Training on Sprint, Agility, and Balance in Youth Football Players: A Controlled Experimental Study. *Journal of Sport for All and Recreation, 7*(3), 578-587.

Atıcı, M., & Bayrakdar, A. (2025). Effects of Core and Resistance Exercise on Sprint and Agility Outcomes in Adolescent Footballers: A Randomized Controlled Trial. Yalova Üniversitesi Spor Bilimleri Dergisi, 4(2), 383-401.

Bradley, P. S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P., & Krustrup, P. (2009). High-intensity running in English FA Premier League soccer matches. *Journal of sports sciences*, *27*(2), 159-168.

Barnes, J. L., Schilling, B. K., Falvo, M. J., Weiss, L. W., Creasy, A. K., & Fry, A. C. (2007). Relationship of jumping and agility performance in female volleyball athletes. *The Journal of Strength & Conditioning Research*, *21*(4), 1192-1196.

Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of sports sciences*, *24*(07), 665-674.

Bimson, L., Langdown, L., Fisher, J. P., & Steele, J. (2017). Six weeks of knee extensor isometric training improves soccer related skills in female soccer players. *Journal of Trainology*, *6*(2), 52-56.

Bizzini, M., Impellizzeri, F. M., Dvorak, J., Bortolan, L., Schena, F., Modena, R., & Junge, A. (2013). Physiological and performance responses to the "FIFA 11+"(part 1): is it an appropriate warm-up?. *Journal of sports sciences*, *31*(13), 1481-1490.

Cronin, J. B., & Hansen, K. T. (2005). Strength and power predictors of sports speed. *The Journal of Strength & Conditioning Research*, *19*(2), 349-357.

Castillo-Rodríguez, A., Fernández-García, J. C., Chinchilla-Minguet, J. L., & Carnero, E. Á. (2012). Relationship between muscular strength and sprints with changes of direction. *The Journal of Strength & Conditioning Research*, *26*(3), 725-732.

Gravina, L., Gil, S. M., Ruiz, F., Zubero, J., Gil, J., & Irazusta, J. (2008). Anthropometric and physiological differences between first team and reserve soccer players aged 10-14 years at the beginning and end of the season. *The Journal of Strength & Conditioning Research*, *22*(4), 1308-1314.

Harris, N. K., Cronin, J. B., Hopkins, W. G., & Hansen, K. T. (2008). Relationship between sprint times and the strength/power outputs of a machine squat jump. *The Journal of Strength & Conditioning Research*, *22*(3), 691-698.

Jones, P., Bampouras, T., & Marrin, K. (2009). An investigation into the physical determinants of change of direction speed. *Journal of sports medicine and physical fitness*, *49*(1), 97-104.

Kabacinski, J., Szozda, P. M., Mackala, K., Murawa, M., Rzepnicka, A., Szewczyk, P., & Dworak, L. B. (2022). Relationship between isokinetic knee strength and speed, agility, and explosive power in elite soccer players. *International journal of environmental research and public health*, *19*(2), 671.

Little, T., & Williams, A. G. (2005). Specificity of acceleration, maximum speed, and agility in professional soccer players. *The Journal of Strength & Conditioning Research*, *19*(1), 76-78.

Marcovic, G. (2007). Poor relationship between strength and power qualities and agility performance. *Journal of Sports Medicine and Physical Fitness*, *47*(3), 276.

Meckel, Y., Doron, O., Eliakim, E., & Eliakim, A. (2018). Seasonal variations in physical fitness and performance indices of elite soccer players. *Sports*, *6*(1), 14.

Meylan, C., McMaster, T., Cronin, J., Mohammad, N. I., Rogers, C., & DeKlerk, M. (2009). Single-leg lateral, horizontal, and vertical jump assessment: Reliability, interrelationships, and ability to predict sprint and change-of-direction performance. *The Journal of Strength & Conditioning Research*, *23*(4), 1140-1147.

McBride, J. M., Blow, D., Kirby, T. J., Haines, T. L., Dayne, A. M., & Triplett, N. T. (2009). Relationship between maximal squat strength and five, ten, and forty yard sprint times. *The Journal of Strength & Conditioning Research*, *23*(6), 1633-1636.

Negra, Y., Chaabene, H., Hammami, M., Amara, S., Sammoud, S., Mkaouer, B., & Hachana, Y. (2017). Agility in young athletes: is it a different ability from speed and power?. *The Journal of Strength & Conditioning Research*, *31*(3), 727-735.

Pamuk, Ö., Makaracı, Y., Ceylan, L., Küçük, H., Kızılet, T., Ceylan, T., & Kaya, E. (2023). Associations between force-time related single-leg counter movement jump variables, agility, and linear sprint in competitive youth male basketball players. *Children*, *10*(3), 427.

Peterson, M. D., Alvar, B. A., & Rhea, M. R. (2006). The contribution of maximal force production to explosive movement among young collegiate athletes. *The Journal of Strength & Conditioning Research*, *20*(4), 867-873.

Pereira, L. A., Nimphius, S., Kobal, R., Kitamura, K., Turisco, L. A., Orsi, R. C., ... & Loturco, I. (2018). Relationship between change of direction, speed, and power in male and female national olympic team handball athletes. *The Journal of Strength & Conditioning Research*, *32*(10), 2987-2994.

Raya, M. A., Gailey, R. S., Gaunaurd, I. A., Jayne, D. M., Campbell, S. M., Gagne, E., ... & Tucker, C. (2013). Comparison of three agility tests with male servicemembers: Edgren Side Step Test, T-Test, and Illinois Agility Test. *Journal of Rehabilitation Research & Development*, *50*(7).

Reilly, Thomas (1976). A motion analysis of work-rate in different positional roles in professional football match-play. *J Human Movement Studies*, *2*, 87-97.

Savla, H. N., Sangaonkar, M., & Palekar, T. (2020). Correlation of core strength and agility in badminton players. *Int J Appl Res*, *6*(12), 383-7.

Sekulic, D., Spasic, M., Mirkov, D., Cavar, M., & Sattler, T. (2013). Gender-specific influences of balance, speed, and power on agility performance. *The Journal of Strength & Conditioning Research*, *27*(3), 802-811.

Stojanović, E., Stojiljković, N., Scanlan, A. T., Dalbo, V. J., Berkelmans, D. M., & Milanović, Z. (2018). The activity demands and physiological responses encountered during basketball match-play: a systematic review. *Sports Medicine*, *48*(1), 111-135.

Yanci, J., Los Arcos, A., Mendiguchia, J., & Brughelli, M. (2014). Relationships between sprinting, agility, one-and two-leg vertical and horizontal jump in soccer players. *Kinesiology*, *46*(2.), 194-201.

Young, W., Hawken, M., & McDonald, L. (1996). Relationship between speed, agility and strength qualities in Australian Rules football. *Strength Cond Coach*, *4*(4), 3-6.

Wisløff, U., Castagna, C., Helgerud, J., Jones, R., & Hoff, J. (2004). Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *British journal of sports medicine*, *38*(3), 285-288.