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Relationship between ball speed in instep and inside foot kicks and anthropometric, motor, and anaerobic performance parameters in male football players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Football performance often depends on the ability to execute powerful and precise kicks. Understanding the factors influencing ball speed can help optimize training methods. The aim of this study is to investigate the relationships between ball speed in instep and inside foot kicks and some anthropometric, motor characteristics, and anaerobic performance parameters in male football players.

Material and Methods: This study was conducted with 17 volunteer football players from the university football team. Their average age was 23.11 ±1.61 years. They had an average height of 177.52 ±6.14 cm, an average body weight of 76.25 ±5.74 kg, and an average body mass index of 24.20 ±1.55 kg/m². Participants underwent measurements for various anthropometric characteristics, including height, leg length, body weight, and thigh and leg circumferences. Motor characteristics measured included 30m sprint speed, vertical jump height, horizontal jump distance, and leg and grip strength. Anaerobic power was calculated using the Lewis formula. To determine ball speed, a radar (Sports Radar 3300) was used. The Shapiro-Wilk test determined the normality distribution, and the Levene test assessed variance homogeneity. Since the data showed parametric characteristics, Pearson correlation analysis was used. Statistical significance was initially set at $p<0.05$. All statistical analyses were performed using SPSS 21.

Results: According to the findings, statistically significant differences were found between instep kick ball speed and inside foot kick ball speed ($r = 0.65$). Significant differences were also observed between leg length and shoe size ($r = 0.61$), and between anaerobic power and leg length ($r = 0.67$), thigh circumference ($r = 0.51$), and leg circumference ($r = 0.53$) ($p < 0.05$). No statistically significant differences were found among other parameters ($p > 0.05$).

Conclusions: No significant relationships were found between ball speed in instep and inside foot kicks and anthropometric, motor, and anaerobic parameters in university male football players. This result may be attributed to the varying levels of the club teams to which the players of the university football team belong.

Keywords: football, instep kick, inside foot kick, ball speed

Introduction

Research has shown that despite differences in playing positions in football, having an athletic body type provides advantages in both defense and offense, positively affecting performance. Football involves activities such as jumping, shooting, turning, dribbling, sprinting, ball control under pressure, running at different speeds, and changing directions. Both aerobic and anaerobic energy systems are continuously used alternately during the game. Football is a team sport played for prolonged periods at a high intensity, requiring fundamental motor skills such as strength, speed, and endurance. It also demands abilities like agility, mobility, flexibility, balance, and coordination [1, 2]. Furthermore, early-onset tiredness has a detrimental effect on the movement system in athletes who are not conditionally competent, causing errors in technical motions [3, 4].

Vertical jump ability is one of the core traits of football. This ability provides a significant advantage in heading during offense or defense. Studies also indicate that leg strength positively influences vertical jump and anaerobic power values [2, 5]. Anaerobic power, leg strength, good jumping capacity, shot, and ball speed are some of the most fundamental characteristics of football and significantly enhance a football player's performance [6].

Shot performance is an important aspect of football. A football player's primary goal when making a shot is to achieve high ball speed.

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Researchers have confirmed that increasing ball speed can be achieved by enhancing the strength of the lower extremity muscle groups [7]. Many variables affect a good shot, including the maximum strength of the muscle groups engaged during the shot, the swing speed of the kicking foot, the angle of the supporting foot, and the approach speed of the player [8].

In a study, the shot speeds of the starting lineup and substitute/bench players in the U19, U17, and U15 teams of the Croatian league were compared. The inside foot kick speed (98.9±6.43, 96.39±7.51, 90.93±6.54) and instep kick speed (111.3±4.35, 107.43±4.65, 100.27±4.76) of the starting players were found to differ statistically significantly ($p<0.05$). This study provides significant insights into the importance of ball speed for securing a position in the starting lineup. It also highlights that kick speed starts to develop as training years increase [9].

In football, engaging in one-on-one or team battles with the opponent and then scoring goals by shooting accurately at the target is a crucial objective. Achieving the desired level of performance in football is not solely dependent on having good anthropometric and motor characteristics. Despite existing research, the relationships between these characteristics and specific performance metrics, such as ball speed in different types of kicks, still require further investigation. The aim of this study is to investigate the relationships between ball speed in instep and inside foot kicks and some anthropometric, motor characteristics, and anaerobic performance parameters in male football players.

Materials and Methods

Participants

This study was conducted during the competition season with athletes participating in the university male football team (n=17, average age 23.11±1.61 years, height 177.52 ±6.14 cm, body weight 76.25 ±5.74 kg, body mass index 24.20±1.55 kg/m^2). Participants were selected from healthy volunteers without any physical or mental illness. Football players were advised to stick to their usual diet and not engage in intense activity prior to the tests. Participants were informed about the tests beforehand.

Research Ethics

The investigation was conducted in accordance with the Helsinki Declaration. This research was approved by the Non-Interventional Clinical Research Ethics Committee of Duzce University (2024/118).

Study Design

The tests were conducted at the same timeframe (08:30 am - 12:00 pm). Before the tests, the football players performed standard warm-up movements, including general exercises (jogging followed by 5-minute stretching exercises) and special exercises (submaximal jumps and sprints). To ensure proper recovery, ten-minute rest intervals were inserted between each test.

Data Collection Tools

The participants were tested in an indoor sports hall, on a taraflex floor, 15 m away from a handball goal, to shoot (inside foot and instep) with their maximum power. Measurements were taken with a radar positioned at ball level, 2 m behind the athlete. The average ball speed of inside foot and instep kicks displayed on the radar screen was recorded in km/h (Sports Radar 3300, Electronics Inc, USA).

Athletes declared their own shoe sizes. Anthropometric measurements, such as leg length, thigh circumference, and lower leg circumference, were taken. Motor characteristics, including vertical jump, horizontal jump, 30 m sprint speed, grip strength, and leg strength, were measured.

Anthropometric Measurements

Each volunteer was measured in compliance with standardized kinanthropometry methods [11].

Height. The height of the participant was measured using a stadiometer (Holtain, UK). Measurements were made with the body weight equally distributed on both legs, head in the 'Frankfort Horizontal Plane' position, arms at the side of the body, palms facing the legs, and barefoot [12].

Body Weight. Body weight of the participants was measured with a Tanita MC780 (Japan) body fat analyser. The measurements were made before breakfast on an empty stomach. Participants wore shorts and t-shirts during the measurements. The metal parts of the platform in contact with the hands and feet were wiped with a wet cloth after each player left the platform [12].

Leg Length. The distance between the tibial plateau and the ground was measured with a tapeline from the right side of the body in a vertical position while the volunteer was standing. The measurement was taken twice.

Thigh Circumference. While the volunteer was standing upright, the measurement was taken with a tapeline from the point where the hip and thigh meet, just below the gluteal region, horizontally around the thigh, and recorded at a precision level of 0.1 cm [13].

Leg Circumference. While the participant was standing upright, the measurement was taken with a tapeline from the widest point of the calf region and recorded at a precision level of 0.1 cm [13].

Shoe Size. Participants declared their shoe sizes used in training.

Motor Measurements

30m Sprint Speed Test. The 30 m sprint was measured using a Photocell Gate System (Fusion Sport, Coopers Plains, QLD, Australia) connected to a laptop computer. There are two gates in the 30 m sprint test on a straight line. The gates were placed at the start line and the 30 m finish line. The times that the athletes passed these gates were recorded. Two trials were made and the best time was recorded. Four-minutes rest time was given between the trials [14].

Countermovement Jump. Countermovement jump test protocol was used to determine the jumping abilities of football players. The time of the countermovement jump was measured with a digital jump mat (Fusion Sport Smart Speed, Brisbane, Australia) with 0.01 s precision. The active jump was performed by using both feet together with hands on the hips. The athlete was in an upright position on the contact mat and the test was performed with a maximal vertical jump with a command given to the athlete. The position of the hands on the hips was preserved during the performance and the jump was performed on both feet to the highest possible height. The measurement was repeated twice and the better result was taken into account. The results were recorded in cm [15].

Standing Long Jump Test. Standing jump tests were done with the metric measurement method. In this test, standing long jump was measured by a long jump from a standing position. Previously, a straight line was drawn which was accepted as the starting point. The athlete stood a little behind this line waiting with a distance of about shoulder height between his feet. The athlete was told that he could spring by bending at the knees and that he could leave his hands free to get speed from his arms while performing this movement. The athlete was asked to jump with the highest power and move forward from where he was, then to stay where he was after the jump, and to wait until the measurement was finished without breaking ground contact with his feet. The shortest distance between the heel of the back foot and the starting line was measured with a tapeline. After four minutes rest, the athlete performed the second trial. The better result of the two trials was recorded in cm. This test was also used in previous studies and its reliability was reported as 0.70-0.94 [16].

Calculation of Anaerobic Power

Anaerobic Power was calculated using the Lewis formula [17]:

$$\text{Anaerobic Power} = \sqrt{4.9} \times \text{mass (kg)} \times \sqrt{\text{VJ (m)}} \times 9.81,$$

where, VJ= Vertical Jump Distance.

Leg Strength Measurement. Leg strength was measured with a leg dynamometer (Takei Physical Fitness Test, Japan). The athlete was asked to place his feet on the dynamometer stand first, then to pull the dynamometer bar, which he grasped with his hands, vertically upwards using all his strength with his legs to the maximum extent. This was done after placing his feet on the dynamometer stand, with his knees flexed approximately 120 degrees, arms stretched, back straight, and trunk slightly tilted forward. Three attempts were made for the test, and the best result on the indicator was recorded in kg [18].

Ball Speed Measurement. Inside foot and instep kick ball speed was recorded by radar (Sports Radar 3300, Electronics Inc, USA). Measurements were taken with a hand-held radar gun (Sports Radar Gun) at a distance of 2 m from the ball line behind the hitting area. All shots were kicked 15 m away from the goal line, facing the goal, with a dead ball, as inside foot and instep kicks. Each kick was performed twice and the highest ball speed was recorded as the average speed in km/h. For this test, the procedure was adapted to football [19].

Statistical Analysis

Statistical evaluations of the data were carried out using SPSS 21. The Shapiro-Wilk test was used to determine normality distribution, and the Levene test was used for variance homogeneity. Since the data showed parametric properties, the Pearson correlation test was applied and interpreted according to Table 1 [10]. Statistical significance was accepted at $p<0.05$.

Table 1. Correlation Table

Correlation	Negative	Positive
Weak	-0.29 - 0.10	0.10 - 0.29
Moderate	-0.49 - 0.30	0.30 - 0.49
Strong	-0.50 -1.00	0.50 - 1.00

Results

Descriptive data are shown in Table 2. Other findings are shown in Table 3.

When Table 3 was analysed, statistically significant correlations were found between instep kick ball speed (m/s) and inside foot kick speed (m/s) ($r=0.65$), between leg length (cm) and foot size (cm) ($r=0.61$), and between anaerobic power (watt) and leg length (cm) ($r=0.67$), thigh circumference (cm) ($r=0.51$), and leg circumference (cm) ($r=0.53$) ($p<0.05$). No statistically significant correlations were found between the other parameters ($p>0.05$).

Table 2. Descriptive Data of Ball Speed, Anthropometric Characteristics, and Anaerobic Performance Parameters in Instep and Inside Foot Kicks

Variables	x̄	sd
Inside Foot Kick Ball Speed (km/h)	62.94	3.32
Instep Kick Ball Speed (km/h)	62.47	3.55
Shoe Size (cm)	42.38	1.48
Leg Length (cm)	81.17	4.88
Thigh Circumference (cm)	52.71	3.80
Leg Circumference (cm)	37.87	1.97
Vertical Jump (cm)	34.17	4.23
30m Sprint Speed (s)	8.51	17.00
Standing Long Jump (cm)	208.58	15.77
Leg Strength (kg)	211.44	33.10
Anaerobic Power (watt)	978.94	92.62

x̄: mean, sd: standard deviation

Discussion

This study aimed to examine the relationships between ball speed in instep and inside foot kicks and some anthropometric, motor characteristics, and anaerobic performance parameters in male soccer players. The findings revealed statistically significant correlations between the ball speed of instep kicks and inside foot kicks (r=0.65), leg length and shoe size (r=0.61), anaerobic power and leg length (r=0.67), thigh circumference (r=0.51), and leg circumference (r=0.53) ($p<0.05$). However, the other variables did not demonstrate statistically significant relationships ($p>0.05$) (Table 3).

When the literature is reviewed, a study conducted with young football players found a significant correlation between height and vertical jump (r=0.36, $p<0.05$), 10 m (r=0.32, $p<0.05$), and 30 m sprint performances (r=0.64, $p<0.05$) [20]. In the present study, a statistically significant and strong correlation was found between the athletes' leg lengths and anaerobic power (r=0.67, $p<0.05$). Considering that vertical jump, 10 m, and 30 m sprint performances are important indicators of anaerobic power and that lower extremity length is a determining factor for height, it is assumed that the study by Wong et al. supports our findings. In another study conducted with elite young football players, no statistically significant relationship was observed between vertical jump performance and ball speed [21]. This study corroborates our conclusions on the connection between ball speed and vertical jump performance.

On the other hand, Marcel et al. [22] concluded in their study that soccer players with better jumping abilities tend to kick the ball stronger and faster. Similarly, Souza et al. [23] discovered in their study that squat jump (r=0.10) and countermovement jump (r=0.07) performances had a weak correlation with shot speed. The last two studies differ from the current study in some ways, such as the number of participants, age categories, and the quality of the leagues to which the athletes belonged. These distinctions are considered to be the possible causes of the disparities. In a study conducted with elite adult football players, Rodriguez et al. [24] discovered a statistically significant correlation between shot speeds performed with the dominant leg and squat jump (r=0.47) and countermovement jump (r=0.58) performances. While these findings contradict our study in this aspect, they also found no statistically significant relationship between shot speed and anthropometric characteristics, thus supporting our findings in this regard. Similarly, in a study by Alessandro et al. [25], no statistically significant relationship was found between futsal players' shot speeds and variables such as body weight, height, and body mass index. In this respect, it can be considered that futsal and football are comparable.

Contrary to the findings of the present study, Cerrah and Yüksel [26], who worked with adolescent soccer players in amateur leagues, obtained a high-level statistically significant positive relationship between leg mass and instep kick ball speed. Similarly, Aydın et al. [27] investigated the anaerobic performance parameters influencing instep kick shot speed from various distances (9 m, 11 m, and 13 m) in amateur football players (U19) and reported that the influence of muscle strength decreased as the kicking distance increased. However, anaerobic performance emerged as a more important component. Furthermore, leg strength and ball-kicking speed were found to positively correlate in a separate study conducted by Saputra et al. [28].

The study conducted by Aka et al. [7] examined the relationship between shot speed and the strength of the quadriceps femoris (Q) and hamstring (H) muscles in 54 male youth football players who play for professional clubs' youth (U19) teams. The data obtained revealed an excellent correlation between shot speed and concentric Q muscle strength, a strong correlation with concentric H muscle strength, a very strong correlation with eccentric Q muscle strength, and a low to moderate correlation with eccentric H muscle strength ($p<0.05$). Conversely, they reported no statistically significant correlation ($p>0.05$) between shot speed and the eccentric hamstring/quadriceps concentric muscle strength ratio (Hecc/Qcon). These findings differ from our results, which did not show a significant relationship between shot speed and any specific muscle strength parameters.

In another study conducted by Zambak, no evidence of a favorable correlation between football players' shooting speed and plyometric training was reported [29]. However, a study by Tokgöz, which

Table 3. Relationships Between Ball Speed, Anthropometric Characteristics and Anaerobic Performance Parameters in Instep and Inside Foot Kicks

Performance Parameter		Inside Foot Kick Ball Speed	Instep Kick Ball Speed	Foot Size	Leg Length	Thigh Circumference	Leg Circumference	Vertical Jump	30m Sprint Speed	Standing long jump	Leg Strength	Anaerobic Power
Inside Foot Kick Ball Speed	r		0.65	-0.20	0.05	0.38	0.24	0.13	-0.07	-0.28	-0.25	0.21
	p		0.01*	0.43	0.80	0.13	0.34	0.60	0.78	0.26	0.32	0.41
Instep Kick Ball Speed	r			0.05	0.24	0.26	-0.01	0.07	-0.25	-0.13	-0.18	0.33
	p			0.84	0.34	0.29	0.95	0.78	0.32	0.60	0.47	0.18
Foot Size	r				0.61	0.29	0.11	-0.23	-0.24	0.38	0.10	0.25
	p				0.01*	0.25	0.65	0.37	0.34	0.12	0.70	0.32
Leg Length	r					0.42	0.43	0.17	-0.33	0.28	-0.01	0.67
	p					0.08	0.08	0.49	0.19	0.37	0.95	0.01*
Thigh Circumference	r						0.37	0.17	0.05	-0.08	0.23	0.51
	p						0.13	0.51	0.83	0.73	0.36	0.03*
Leg Circumference	r							-0.02	-0.13	0.31	0.14	0.53
	p							0.91	0.66	0.22	0.57	0.02*
Vertical Jump	r								0.58	0.15	0.22	0.44
	p								0.26	0.56	0.38	0.07
30m Sprint Speed	r									-0.22	0.05	-0.33
	p									0.37	0.82	0.18
Standing long jump	r										0.29	0.22
	p										0.24	0.37
Leg Strength	r											0.30
	p											0.22

** significant correlation at 0.01, * significant correlation at 0.05

looked into the factors affecting shot speed with 26 volunteer football players in the BAL (regional amateur league) in Elazığ, revealed that the strength training method with PAP (post-activation potentiation) increased the players' anaerobic performance values and shot speed, and was more effective than the classic circular training method [30]. Alessandro et al. [25] discovered no statistically significant correlation between futsal players' shot speed and variables including height, body mass index, and body weight. These findings align with our study, which also found no significant relationship between shot speed and anthropometric variables.

This study provides valuable insights into the relationships between various performance parameters and ball speed in instep and inside foot kicks among male soccer players. While significant correlations were found with certain anthropometric and anaerobic performance measures, other variables did not show significant relationships. These results suggest that factors such as leg length, thigh, and leg circumference, and anaerobic power play crucial roles in influencing ball speed. Future research should explore these relationships in larger and more diverse samples, investigate the impact of specific training interventions on these parameters, and examine additional factors that may contribute to performance variability in soccer.

Conclusions

This research is limited to players playing in the university football team. The (H_{ecc}/Q_{con}) parameters

of the football players were not measured in this study, nor was the impact of different training techniques on shot speed investigated. In this regard, our study is limited by the parameters we measured. As a result, it has been determined that the anthropometric, motor, and anaerobic power variables within the scope of the study did not affect the ball speed in the instep and inside foot kicks of male university football players. The study data suggests that the primary reasons we were unable to verify our hypothesis were either the limited sample size, the fact that the football players were members of the university football team, or the inability of the players to perform at their maximal potential during the measurements. These findings should be taken into account when designing future research.

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