

Positional differences in shot speed and their association with body composition and neuromuscular performance: A cross-sectional study of Colombian professional soccer players

JHON FREDY RODRIGUEZ APONTE¹, LUZ STEFANY SARMIENTO OJEDA², JAVIER ANDRES HERNANDEZ ACUÑA³, DUVAN CAMILO NEIRA⁴, YORDAN RENE PARDO⁵, WILLIAM FELIPE MARTIN⁶, LUIS ANDRES TELLEZ⁷, ANDRES VIVAS⁸, JHONATAN CAMILO PEÑA IBAGON^{9*}.
^{1,5,6,9} Research Group in Sports Training and Measurement (IMED), Professional Program in Sports Training, Faculty of Health and Sports Sciences. Fundación Universitaria del Área Andina. Bogotá, COLOMBIA.
^{2,3} Student, Professional Program in Sports Training, Faculty of Health and Sports Sciences. Fundación Universitaria del Área Andina. Bogotá, COLOMBIA.
⁴ Fortaleza Fútbol Club. Bogotá, Colombia. Bogotá, COLOMBIA.
⁷ Research group ESCALA, Corporación Unificada Nacional de Educación Superior. Bogotá, COLOMBIA.
⁸ Escuela colombiana de rehabilitación. Bogotá, COLOMBIA.

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Abstract:

Introduction: Shooting is a key skill in soccer, and performing this action at higher speeds provides several advantages in competitive play. However, the factors that influence shot speed continue to be explored in scientific research. **Objective:** To identify the body composition and neuromuscular performance factors associated with shot speed in professional soccer players. **Methods:** A cross-sectional analytical study was conducted with 20 male professional soccer players from Colombia. Body composition was assessed using skinfold measurements following the International Society for the Advancement of Kinanthropometry (ISAK) protocol. Neuromuscular performance was evaluated through two vertical jump tests: the squat jump (SJ) and the countermovement jump (CMJ), based on standardized protocols. Neuromuscular parameters were obtained using the G-SENSOR system. Shot speed was measured with a Stalker Sport 2 radar gun. Each player performed eight shots on goal using their dominant leg after receiving a pass positioned one meter outside the penalty area. Additionally, heading shots were assessed by delivering long passes from 30 meters into the penalty area from both flanks, allowing each player eight opportunities to head the ball toward the goal. **Results:** Shot speed with the foot showed an inverse relationship with body fat percentage, thigh, and calf skinfold thicknesses, and a positive association with peak force during the CMJ ($p \leq 0.005$). No significant associations were found between heading shot speed and any of the assessed variables.

Key Words: kicking velocity, lower-body power, elite football players, anthropometric profile, muscle performance

Introduction

Football is one of the most widely viewed and followed sports globally. Over time, it has continued to grow in popularity, consistently attracting new audiences and participants. Its universal appeal and cultural significance contribute to its ongoing expansion across diverse populations and regions (Barengo et al., 2014). This sport is practiced globally, with participation from over 1.5 million teams and more than 300,000 officially registered clubs across numerous nations and continents (Bizzini & Dvorak, 2015). However, the majority of players participate outside officially organized structures. More than 4 percent of the global population is involved in playing football, including approximately 270 million amateur players (Ahmed & Memish, 2019).

Among the technical actions that define football, shooting is of critical importance, as it represents the culmination of an offensive play and serves as the decisive moment for successfully scoring a goal (Barfield, 1998). This action demands precision, strength, and refined technique, functioning as a crucial metric for evaluating a team's offensive effectiveness (Rodríguez-Lorenzo et al., 2018). Moreover, shooting proficiency is not solely dependent on individual technical ability—it also reflects the outcome of collective tactical coordination and the capacity to create and exploit goal-scoring opportunities (Sedano Campo et al., 2009; Sedano et al., 2011).

The execution of a successful shot requires a complex technical sequence, generally divided into six distinct phases. According to Barfield (1998), the first phase involves proper body positioning to ensure an effective approach angle toward the ball. This is followed by the stabilization of the support leg and the transfer of force, leading to the swinging motion of the shooting leg. During this movement, hip flexion and knee extension occur in a coordinated manner, culminating in foot-to-ball contact. The efficiency of each of these

phases is influenced by multiple interrelated factors, including muscle strength, neuromuscular coordination, and the precise synchronization between agonist and antagonist muscles (Kellis & Katis, 2007; Lees et al., 2010). These elements directly affect the ball's velocity at the moment of impact, which in turn influences shooting effectiveness and scoring probability.

In football, players assume different tactical roles that condition the physical and technical demands associated with each position (Hernández-Mosqueira et al., 2022; Slimani & Nikolaidis, 2019). These positional demands also influence the way shooting is executed and the frequency with which it occurs (Cullen et al., 2013). For example, forwards tend to develop greater power and accuracy in shooting, given their primary role in scoring. Midfielders, while also capable of shooting, must combine this ability with passing and game organization, whereas defenders generally shoot less frequently, often participating in finishing actions during set pieces. Even goalkeepers may attempt shots under exceptional circumstances, typically in the final moments of a match (Lago-Peñas et al., 2011). As a result, each position not only requires specific shooting skills but also reflects unique technical and physical profiles. Bloomfield et al. (2007) emphasize that these differences are evident in match performance: forwards show higher shot frequency and conversion rates, midfielders contribute through balanced technical actions, and defenders prioritize duels and clearances, though they are also involved in offensive aerial plays during set pieces.

Although previous studies have addressed positional differences in body composition and neuromuscular characteristics in football players, few have explored how these variables affect shot velocity. Most of the available evidence has examined these relationships in general populations or in non-professional settings. Research specifically targeting professional Colombian football players is virtually nonexistent. This represents a significant gap in the literature, considering the relevance of shot velocity as a performance variable and the potentially distinctive morphological and neuromuscular profiles associated with South American football contexts.

Given the lack of empirical evidence in this area, particularly in Colombia, it is still unclear how body composition and neuromuscular performance influence shot velocity among professional football players based on their position on the field. Addressing this gap is essential for developing training strategies tailored to the physical and technical demands of each position. Therefore, the objective of this study is to identify which components of body composition and neuromuscular performance are associated with shot velocity in professional Colombian football players, according to their positional role. These findings could contribute to a better understanding of performance determinants in football and support the design of more individualized and effective training interventions.

Material & methods

Design and Participants

During the first semester of 2023, an analytical cross-sectional study was conducted with 24 professional Colombian football players. The sample was selected through non-probability convenience sampling, and participants were recruited via a collaboration agreement between the Fundación Universitaria del Área Andina and the professional football club Fortaleza CEIF. The inclusion criteria were: (a) being a professional football player, (b) having a contractual relationship with a football club, and (c) being of legal age. Players with musculoskeletal injuries reported within the previous two months that prevented them from completing the proposed protocols were excluded from the study. Additionally, goalkeepers were excluded post hoc, as their role in the game did not provide relevant practical contributions to the specific objectives of the study. This project received ethical approval from the ethics committee of the Fundación Universitaria del Área Andina.

Instruments and Procedures

Anthropometric Measurements: Skinfold measurements were performed according to the ISAK protocol, under the supervision of the medical department of Fortaleza CEIF football club, led by the team's nutritionist. Skinfold calipers were used to assess subcutaneous fat. Athletes were instructed to arrive in a fasting state. Upon arrival at the consultation room, participants were asked to remain in their underwear, after which skinfold measurements were taken using a Lange caliper with a precision of 1.0 mm. The following anatomical sites were measured: subscapular, triceps, suprailiac, abdominal, anterior thigh, and calf. Each skinfold was measured three times, and the average value was used for calculations following the Yuhasz method. (Lewandowski et al., 2022).

Variables neuromusculares: The squat jump (SJ) and countermovement jump (CMJ) protocols were applied using the G-Sensor device. According to scientific literature, athletes performing these protocols adopt a starting position with feet shoulder-width apart and toes slightly pointing outward (Bosco et al., 1983; Comfort et al., 2018). With hands placed on the hips, players then flex their knees and hips, lowering their center of gravity into a deep squat. While keeping their heels close to the ground and maintaining an upright back, they hold this position for three seconds before explosively extending their hips and knees to perform a vertical jump, aiming

to reach the highest possible height. The landing phase is performed smoothly, returning to a squat position while ensuring that the knees are aligned with the toes and the heels remain close to the ground.

For the CMJ, athletes start with feet shoulder-width apart and toes pointing forward. With hands positioned behind the hips, they descend by flexing their knees and hips until the body reaches a 90-degree angle, keeping the heels on the ground, the back upright, and the knees aligned with the toes. Immediately following this movement, players perform an explosive countermovement jump, extending the hips, knees, and ankles. The landing is executed softly, returning to a squat position while maintaining proper alignment of the knees with the toes and keeping the heels near the ground.

Shot Velocity: To assess this variable, a Stalker Sport 2 radar gun (Stalker, Inc.) was used, with an accuracy of $\pm 3\%$ and a frequency of 24.125 GHz (Figure 1). This instrument has been validated in previous studies within the same sport. The radar was operated by a member of the research team positioned 1 meter from the penalty area, next to the goal, outside the field of play to clearly observe the shots on goal and track the ball's trajectory in order to record its velocity. The remaining observers were positioned in the same area to verbally provide information. Initially, two observers recorded the data, and in case of any discrepancies, a third observer made the final decision. For the foot shot test, each player performed 8 shots on goal using their dominant leg. A teammate passed the ball to a spot approximately 1 meter outside the penalty area, allowing the player to control the ball, enter the box, and shoot in their preferred direction.

For the header test, long passes were delivered from a distance of 30 meters from the penalty area, targeting both the left and right flanks. Each player had 8 opportunities to head the ball toward the goal from within the penalty area. In both foot and header tests, only shots directed toward the goal were recorded for velocity measurements.

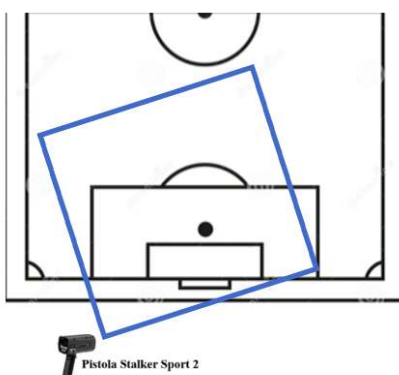


Figure 1. Positioning of the radar gun and observers during data collection.

Statistical Analysis

Data were analyzed using Jeffreys's Amazing Statistics Program (JASP) version 0.18.1, following a thorough review and cleaning of the collected data. Initially, the Shapiro-Wilk test was employed to assess the normality of the data distribution. Subsequently, a univariate analysis was conducted, including measures of central tendency and dispersion (mean, standard deviation, and range) for continuous variables, and frequency analysis for categorical variables, all reported with their corresponding 95% confidence intervals. Participants were grouped according to their playing positions on the field, and a one-way ANOVA was performed to evaluate differences in shot velocities across the different types of shots and positional groups. Post hoc analyses with Bonferroni correction were planned if significant differences were detected to control for type I error. Statistical significance was set at $P < 0.05$. All analyses adhered to accepted standards of statistical rigor for sports science research.

Results

Table 1 displays the body composition characteristics stratified by playing position. Statistically significant differences ($p \leq 0.05$) were identified in several anthropometric variables, including body weight, height, body fat percentage, as well as in the subscapular, thigh, and calf skinfold thicknesses. Upon closer examination, it was noted that midfielders consistently exhibited lower levels of subcutaneous fat accumulation across most of the assessed skinfold sites. Specifically, midfielders had lower values in the subscapular, suprailiac, abdominal, and calf skinfolds when compared to defenders and forwards. However, an exception was observed in the thigh skinfold, where forwards recorded lower values than midfielders and defenders, suggesting a more localized reduction of fat in this region for this positional group. These findings suggest that body composition profiles may vary depending on the positional demands within the game, with midfielders generally maintaining lower overall fat deposits, possibly due to the high aerobic and anaerobic demands associated with their role on the field.

Table 1. Body composition by playing positions

Variables	Defenders (n=9)	Midfielders n=7	Forwards n=5	p-value
Body Composition				
Height (m)	1.88±0.09	1.72±0.06	1.75 ±0.85	0.046*
Weight (kg)	79.5±7.4	71.3±8.2	78.5±13.4	0.024*
Triceps skinfold (mm)	6.07±1.1	5.7±1.5	7.1±1.1	0.003*
Plieque tricipital (mm)	9.1 ±1.9	8.1 ±1.5.2	9.2±0.9	0.343
Suprailiac skinfold (mm)	7.7±2.8	6.5±2.8	7.0±1.6	0.543
Abdominal skinfold (mm)	11.1±4.9	10.1±3.4	11.5±4.5	0.845
Thigh skinfold (mm)	7.9±1.4	7.1±0.5	6.1±0.3	0.024*
Calf skinfold (mm)	5.1±1.1	4.1±1.3	4.2±1.3	0.043*
Body fat (%)	7.5±1.7	6.3±1.3	7.2±1.5	0.013*

*Statistically significant differences ($p \leq 0.05$).

In Table 2, the results of the ball velocity tests and neuromuscular performance assessments are presented. It was observed that, in the instep kick test, forwards achieved significantly higher ball velocities compared to defenders and midfielders ($p = 0.006$), suggesting their superior shooting power and technique when finishing with the foot. Conversely, defenders recorded the highest values in the header velocity test ($p = 0.001$), which may reflect their frequent involvement in aerial duels and set-piece situations. Regarding the neuromuscular variables, defenders consistently outperformed players from the other two positions in both jump protocols (CMJ and SJ), achieving superior values across all analyzed parameters ($p = 0.001$). This indicates that defenders in this sample possessed greater lower-body power and force-generating capacity, which may contribute to their aerial dominance and ability to execute explosive movements during defensive and offensive actions.

Table 2. Ball velocity and neuromuscular performance by playing positions

Variables	Defenders n=9	Midfieldersn=7	Forwards n=5	p-value
Ball velocity				
Instep kick velocity (km/h)	93.1 ±14.9	91.8±11.8	98.6±10.4	0.006
Header velocity (km/h)	46.7±6.1.	31.4 ±12.1	37.4±12.1	0.001
Neuromuscular performance				
CMJ jump height (cm)	48.3±8.6	41.3±4.6	42.3 ±4.8	0.001
SJ jump height (cm)	43.2±5.2	36.8±10.7	38.1±3.2	0.001
CMJ maximum force (kN)	1.9±0.2	1.4±0.9	1.5±0.9	0.001
SJ maximum force (kN)	1.8 ±0.5	1.5 ±0.2	1.6±0.2	0.001
CMJ peak power (W)	4.8±0.5	4.1±0.4	4.5±0.6	0.001
SJ peak power (W)	4.9±0.3	4.2±0.5	4.3±0.3	0.001

*Statistically significant differences ($p \leq 0.05$).

Table 3 presents the significant correlations between ball velocity during the instep kick and selected body composition and neuromuscular variables. The analysis revealed that ball velocity with the foot was negatively associated with fat-related measures, including the thigh skinfold ($r = -0.640$; $p = 0.014$), calf skinfold ($r = -0.569$; $p = 0.034$), and overall body fat percentage using the Yuhasz formula ($r = -0.501$; $p = 0.048$). These findings suggest that players with lower adiposity, particularly in the lower limbs, tended to generate higher ball velocities when kicking. Additionally, a positive correlation was found between instep kick velocity and the maximum force produced during the countermovement jump (CMJ) ($r = 0.067$; $p = 0.003$), highlighting the relevance of lower-body force production capacity in achieving higher shot speeds. These results underscore the interplay between body composition—particularly fat accumulation in the lower extremities—and neuromuscular performance as determinants of technical actions such as kicking velocity in professional football players.

Table 3. Correlation between instep kick velocity, body composition, and neuromuscular performance variables

Variables	Instep kick velocity	Thigh skinfold	Calf skinfold	% Body fat (Yuhasz)	Max force CMJ (kN)
Instep kick velocity	1	$r = -0.640$ $p = 0.014$	$r = -0.569$ $p = 0.034$	$r = -0.501$ $p = 0.048$	$r = 0.067$ $p = 0.003$
Thigh skinfold	$r = -0.640$ $p = 0.014$	1	$r = -0.691$ $p = 0.006$	$r = 0.875$ $p = 0.001$	$r = -0.055$ $p = 0.034$
Calf skinfold	$r = -0.569$ $p = 0.034$	$r = -0.691$ $p = 0.006$	1	$r = -0.801$ $p = 0.001$	$r = -0.054$ $p = 0.043$
% Body fat (Yuhasz)	$r = -0.501$ $p = 0.048$	$r = 0.875$ $p = 0.001$	$r = -0.801$ $p = 0.001$	1	$r = 0.053$ $p = 0.039$
Max force CMJ (kN)	$r = 0.067$ $p = 0.003$	$r = -0.055$ $p = 0.034$	$r = -0.054$ $p = 0.043$	$r = 0.053$ $p = 0.039$	1

Discussion

The main findings of this study revealed that forwards achieved the highest ball-kicking velocities, whereas defenders displayed superior performance in heading velocity and neuromuscular output. Moreover, we observed an inverse association between fat accumulation in the lower body and shot velocity, while maximal force production during the countermovement jump (CMJ) was positively correlated with higher ball speeds.

The positive relationship between kicking velocity and vertical jump performance aligns with previous research indicating that improvements in explosive strength, particularly through plyometric training, enhance neuromuscular efficiency and the capacity to generate rapid force (Beato et al., 2018; Fiorilli et al., 2020). This connection is particularly relevant for football players, as the muscle groups involved in jumping and kicking overlap substantially, and their development directly contributes to technical actions such as shooting.

Furthermore, prior studies have emphasized that greater lower-body power enhances not only ball velocity but also performance in sprinting, jumping, and rapid directional changes, key components of football performance (Cormie et al., 2011; Markovic & Mikulic, 2010). Our findings also support biomechanical models suggesting that lower subcutaneous fat levels improve muscle contractility and mechanical efficiency, thereby enhancing force transmission during high-speed movements like kicking (Bangsbo et al., 2006).

Interestingly, our results contrast with those of Rodríguez et al. (2016), who found no significant influence of body composition on shot velocity among elite Spanish players. This discrepancy may stem from methodological differences; for instance, Rodríguez et al. assessed general anthropometric characteristics but omitted skinfold thickness, a more precise measure of regional fat distribution relevant to performance.

It is important to highlight that this study did not assess shot accuracy. While greater ball velocity can increase the probability of scoring by surpassing goalkeepers, accuracy is equally essential. Recent findings indicate that factors such as body orientation, ball contact angle, and movement consistency can significantly influence shot precision (Fiorilli et al., 2020; Russell et al., 2010). Hence, technical execution must complement physical power in successful shooting performance.

From a physiological standpoint, excess fat mass, particularly in the thighs and calves, may act as non-functional tissue, reducing the rate of force development and impairing the efficiency of the stretch-shortening cycle during explosive actions (Comfort et al., 2014; Ferraz et al., 2019). These mechanical inefficiencies may explain the inverse correlation observed between lower-body fat and kicking speed.

The strong correlation found between CMJ force output and ball velocity reinforces the idea that neuromuscular capacity is a fundamental determinant of shooting performance (Loturco et al., 2017). The CMJ serves as a reliable indicator of muscle-tendon reactivity and explosive strength—qualities essential during the final phase of the kicking action, where joint torques and angular velocities peak (Lees et al., 2010).

Our study is not without limitations. All participants belonged to a single Colombian professional team, which restricts the generalizability of our findings. Moreover, data collection occurred during the pre-season, a period marked by fluctuations in physical fitness and body composition. It is likely that the observed relationships vary across different phases of the competitive calendar, as supported by previous research (Silva et al., 2016; Mohr et al., 2005). Another important limitation is the exclusion of biomechanical and psychological variables. Elements such as limb coordination, trunk alignment, and cognitive stress may significantly influence shooting mechanics, particularly under match conditions (Lees et al., 2010). Future research should consider integrating biomechanical and psychological assessments to capture the multifactorial nature of kicking performance.

We recommend future longitudinal studies to evaluate how targeted interventions, such as fat reduction programs or explosive strength training—affect shooting velocity and accuracy across a full season. These investigations would offer deeper insights into how neuromuscular and compositional improvements translate into on-field performance (Beato et al., 2018; Loturco et al., 2017).

Finally, this research underscores the relevance of evidence-based practices in professional football. Scientific insights can inform coaching decisions, optimize player development, and contribute to long-term athletic success. As demonstrated in previous studies from JPES, such as those by Fiorilli et al. (2020), integrating physical assessments with tactical and technical training can lead to significant gains in competitive environments.

Conclusions

This study highlights the critical role of body composition and neuromuscular performance in determining shot velocity among Colombian professional soccer players. Specifically, lower fat accumulation in the lower limbs and higher maximal force output during the countermovement jump were associated with faster kicking speeds. Additionally, positional differences were evident: forwards recorded the highest foot-shot velocities, whereas defenders showed superior neuromuscular capabilities and heading performance.

These findings suggest that strength and conditioning programs should include targeted interventions to reduce lower-body fat and enhance explosive strength through plyometric and resistance training. Monitoring body composition and neuromuscular outputs may help optimize key technical actions such as shooting, crucial for game-defining moments.

We recommend that future research explore these relationships throughout the competitive season and in response to structured training programs. Understanding how physical and neuromuscular changes affect performance will support the development of position-specific strategies that maximize athletic potential in professional football players.

Conflicts of interest

The authors report no conflicts of interest.

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