Movement & Sport Sciences - Science & Motricité 2022, **117**, 47–56

https://doi.org/10.1051/sm/2022014

Movement & Sport Sciences
Science & Motricité

Available online at:
www.mov-sport-sciences.org

ARTICLE

Body composition and physical performance measures in elite female football players: differences across playing positions and associations with kicking velocity and curve sprint performance

Santiago Zabaloy[1,*], Rodrigo Villaseca-Vicuña[2,3], Julián Giráldez[1,2], Pedro E. Alcaraz[4], Alberto Filter-Ruger[2], Tomás T. Freitas[4,5,6], and Irineu Loturco[4,5,6,7]

[1] Faculty of Physical Activity and Sports, University of Flores (UFLO), Buenos Aires, Argentina
[2] Faculty of Sports Sciences, Pablo de Olavide University, Seville, Spain
[3] School of Education in Human Movement Science and Sports, Catholic University Silva Henríquez (UCSH), Santiago de Chile, Chile
[4] UCAM Research Center for High Performance Sport, Catholic University of Murcia, Murcia, Spain
[5] Nucleus of High Performance in Sport (NAR), São Paulo, Brazil
[6] Department of Human Movement Sciences, Federal University of Sao Paulo, Sao Paulo, Brazil
[7] University of South Wales, Pontypridd, Wales, United Kingdom

Received 10 January 2022, Accepted 9 June 2022

Abstract – This study aimed to: i) analyze the differences in anthropometric, body composition, physical, and technical parameters in elite female football players across distinct playing positions; ii) examine the correlations between kicking velocity (KV) and physical performance, and the relationships between linear sprint and curve sprint (CS) times. Twenty-six female players ($n = 26$, age: 27 ± 4 years) of an elite football team completed the following assessments: anthropometric, body-composition, squat one-repetition maximum (1RM), 30-m linear sprint, 17-m CS, vertical jump, endurance, and KV measurements. In terms of body composition, only muscle mass was significantly different ($P = 0.046$) in favor of forwards compared to midfielders. Regarding physical performance, overall, jump and sprint capacities were superior in defenders and forwards compared to midfielders ($P < 0.05$). Linear and CS times ($P < 0.05$, $r = -0.450$ to -0.573) and load at $1\,m \cdot s^{-1}$ in the squat ($P < 0.05$, $r = 0.508$) were significantly correlated to KV. Lastly, moderate to strong correlations were observed between linear and CS times ($r = 0.396$ to 0.916). In conclusion, in this international team, physical performance was higher for defenders and forwards compared to midfielders, especially in terms of sprint and jump abilities. Additionally, significant relationships were detected between strength- and speed-related qualities and KV.

Keywords: team-sports, women, athletic performance, elite athletes

Résumé – Composition corporelle et mesures de la performance physique chez les joueuses de football élite : différences entre les positions de jeu et les associations avec la vitesse de frappe et la performance de sprint en courbe. Cette étude visait à : (i) analyser les différences dans les paramètres anthropométriques, de composition corporelle, physiques et techniques chez les footballeuses d'élite dans différentes positions de jeu ; (ii) examiner les corrélations entre la vitesse de frappe (KV) et la performance physique, et les relations entre les temps de sprint linéaire et de sprint en courbe (CS). Vingt-six joueuses ($n = 26$; âge : 27 ± 4 ans) d'une équipe de football d'élite ont réalisé les évaluations suivantes : anthropométrique, composition corporelle, squat une répétition maximum (1RM), et mesures de sprint linéaire 30 m, 17-m CS, saut vertical, endurance et KV. En termes de composition corporelle, seule la masse musculaire était significativement différente ($p = 0{,}046$) en faveur des attaquants par rapport aux milieux de terrain. Concernant les performances physiques, les capacités globales, de saut et de sprint étaient supérieures chez les défenseurs et les attaquants par rapport aux milieux de terrain ($p < 0{,}05$). Les temps linéaires et CS ($p < 0{,}05$; $r = -0{,}450$ à $-0{,}573$) et la charge à $1\,m \cdot s^{-1}$ dans le squat ($p < 0{,}05$; $r = 0{,}508$) étaient significativement corrélés au KV. Enfin, des corrélations modérées à fortes ont été observées entre les temps linéaires et CS ($r = 0{,}396$ à $0{,}916$). En

*Corresponding author: santiagozabaloy@hotmail.com

conclusion, les performances physiques de cette équipe internationale, étaient plus élevées pour les défenseurs et les attaquants que pour les milieux de terrain, notamment en termes de capacités de sprint et de saut. De plus, des relations significatives ont été détectées entre les qualités liées à la force et à la vitesse et le KV.

Mots clés : sports d'équipe, femmes, performance athlétique, athlètes d'élite

1 Introduction

Recently, substantial growth and development have been observed in elite female football (*i.e.*, establishment of professional leagues, increasing investment, and provision for improving support for the development of youth players) (Harkness-Armstrong, Till, & Emmonds, 2021). Harkness-Armstrong *et al.* (2021) reported that this expanded professionalism has translated to improvements on the pitch. Despite the evident growth in female football, studies with women only account for approximately 20% of all research in football, with ~15% of these studies focusing on professional players. Therefore, this noticeable lack of scientific evidence opens an avenue for future research (Kirkendall & Krustrup, 2021).

Football is an intense multidirectional and intermittent team-sport, which combines efforts at different levels of intensity with irregular pauses throughout the 90-min of playing time (Manson, Brughelli, & Harris, 2014; Villaseca-Vicuña, Molina-Sotomayor, Zabaloy, & Gonzalez-Jurado, 2021). In addition, different "explosive" actions such as sprinting, jumping, and changing direction, are frequently combined with a variety of technical elements, such as dribbling, passing, and kicking (Manson *et al.*, 2014; Villaseca-Vicuña *et al.*, 2021). Thus, success in football is determined, to a great extent, by a wide spectrum of physical, technical, and tactical factors (Boone *et al.*, 2012; Villaseca-Vicuña *et al.*, 2021). Hence, identifying the most important qualities for successful performances in football is of great interest for establishing which variables should be targeted when designing individualized training schemes.

More specifically, a physical profile that is well adjusted to the position on the field might enhance game performance (Boone *et al.*, 2012). For example, Boone *et al.* (2012) reported that male football players have different physiological characteristics according to their playing position. In female football, Manson *et al.* (2014) reported normative data relative to distinct age-categories without investigating differences concerning playing positions. In this regard, to date, only Villaseca-Vicuña *et al.* (2021) reported that goalkeepers were significantly ($P < 0.002$) different from defenders, midfielders and forwards across a series of anthropometric and physical performance variables in elite female footballers. Nonetheless, the aforementioned study only estimated, but not measured, maximum oxygen uptake (VO_{2max}) and did not report, for instance, the barbell velocity achieved at a given intensity of the squat (SQ) exercise. Moreover, football-specific qualities such as kicking velocity (KV) or curve sprint (CS) ability were not assessed. The latter variable is particularly interesting to consider, since CS has recently been reported as the most frequent sprinting action in football (Caldbeck, 2020; Fitzpatrick, Linsley, & Musham, 2019) and its importance has been extensively highlighted in different studies (Fílter *et al.*, 2021; Kobal *et al.*, 2021; Loturco *et al.*, 2020). Thus, it is extremely relevant to investigate whether a more comprehensive testing battery would be able to discriminate between playing positions in elite female football players.

Despite the relevance of KV for success in football (Ramírez-Campillo *et al.*, 2015; Torreblanca-Martínez, González-Jurado, & Otero-Saborido, 2018), little information is available regarding the associations between KV, linear and CS, jumping ability, and barbell velocity in lower-limb exercises in female football players. Conversely, moderate to large associations between linear and CS in male and female football players have recently been reported (Fílter *et al.*, 2020; Kobal *et al.*, 2021; Loturco *et al.*, 2020), although these studies have not explored the differences between playing positions nor the associations between body composition, KV, and physical tasks that are crucial to competitive success (*e.g.*, linear and curve sprints). To the authors' knowledge, only one study (Torreblanca-Martínez *et al.*, 2018) reported that KV was moderately ($r = 0.311$–0.587) associated with height, body-mass (BM), linear sprint times, jump height, and VO_{2max}, but the sample comprised under-11 male football players. In this sense, it is crucial to better understand these interrelationships in more specialized populations, especially in elite female players, in order to create more effective training strategies to ultimately improve performance.

Based on all of the above, more information is needed in elite female football regarding the differences in anthropometrics, body composition, and a myriad of physical (*e.g.*, sprint, jump, strength, and aerobic fitness) and technical qualities (*e.g.*, kicking velocity) across specific playing positions, and whether KV is associated to some selected physical attributes. This information may help coaches and practitioners to create more tailored physical training programs (*i.e.*, adapted to specific game demands), which has become a key component for the development and talent identification of female football players (Manson *et al.*, 2014). Therefore, the present study aimed to: i) analyze the differences between playing positions in anthropometric and body composition parameters, linear and CS speed, jump height, strength, and aerobic fitness measures, and KV; ii) examine the associations between KV and a wide range of performance variables; and between linear and CS sprint times. We hypothesized that positional differences would be mainly observed between strength and speed performance (Villaseca-Vicuña *et al.*, 2021), whereas a number of significant correlations would exist between the different strength-, speed-, and power-related measures (Loturco *et al.*, 2020; Torreblanca-Martínez *et al.*, 2018).

2 Methods

2.1 Experimental approach to the problem

A descriptive, cross-sectional design was adopted to describe the differences in anthropometric, body composition, and physical performance tests among distinct playing positions of a female soccer National Team from South-America. Moreover, a correlational analysis was performed to test for correlations between performance variables. Athletes performed the tests on five separate days, interspaced by 48- to 72- h, as follows: day 1, anthropometric and body composition measurements and 30-m linear sprints; day 2, one-repetition maximum (1RM) in the squat exercise; day 3, countermovement jump (CMJ) and aerobic fitness tests to determine the VO_{2max}; day 4, 17-m CS test; day 5, KV test. All testing sessions were conducted at the outdoor facilities of the High-Performance Centre of the National Football Federation, with the exception of anthropometric, body composition, and VO_{2max} determination, which were performed indoor. Participants were asked to avoid any strenuous exercise the day before testing and to consume their last meal at least 2-h before the scheduled testing time (~ 10 a.m.). Before testing, participants performed a standardized warm-up consisting of 5-min submaximal running followed by 5-min joint mobilisation exercises and a specific warm-up for each test.

2.2 Participants

Twenty-six female soccer players ($n = 26$, age 27 ± 4 years) of a National Team squad participated in this study. Participants were divided according to their positional roles on the pitch: defenders ($n = 9$), midfielders ($n = 9$), and forwards ($n = 8$). All players participated in the Women's World Cup held in France 2019 and the Tokyo 2020 Olympics. Participants had football playing experience of 7 ± 2 years from youth to professional level and participated in different professional leagues (South-America and Europe). At the time of the assessments, the National team was ranked 36th out of 155 according to the FIFA women's world ranking. The study met the ethical standards and was approved by an Institutional Research Ethics Committee, conformed to the recommendations of the Declaration of Helsinki. After being informed of the experimental procedures, participants signed a written informed consent form.

2.3 Measurements

All tests used herein are commonly performed by female football teams and provide valid data to assess anthropometry and players' fitness level. All participants were familiarized with the procedures and performed all tests on a regular basis. Each player was encouraged to perform every test with maximum effort.

2.3.1 Anthropometric and body composition

Body mass and height were measured using an electronic scale (HD-366, Tanita Corporation, Japan) and a height rod and a vertex (Rosscraft Innovations, Vancouver, Canada), following the protocol recommended by the International Society for the Advancement of Anthropometry (ISAK) (Holway & Garavaglia, 2009). Afterwards, the summation of six skinfold measures (Σ6SF), was obtained from the triceps, subscapular, supraspinal, abdominal, medial thigh, and calves. Skinfolds were measured with a slim guide plicometer (Rosscraft®, British Columbia, Canada) with an accuracy of 0.2-mm. The Σ6SF was used for the estimation of fat (%FM) and muscle mass percentage (%MM), using the equation proposed by Eston, Rowlands, Charlesworth, Davies, & Hoppitt (2005). These procedures were performed by an expert from the Football Federation staff, certified by ISAK (Level II). The intraclass correlation coefficient (ICC) and coefficient of variation (CV) values for all measured variables were > 0.98 and $< 7.9\%$, respectively.

2.3.2 Isoinertial squat loading test

The 1RM was estimated for the SQ (1RM-SQ) using a linear position transducer (Chronojump Boscosystem®, Barcelona, Spain) (Vivancos *et al.*, 2014), from which the mean propulsive velocity (MPV) of each repetition was obtained. Briefly, MPV is the average velocity from the start of the concentric phase until the acceleration of the bar is lower than gravity [$-9.81\,\text{m} \cdot \text{s}^{-1}$] (García-Ramos, Pestaña-Melero, Pérez-Castilla, Rojas, & Haff, 2018). Regarding testing procedures, a previously described (Sánchez-Medina, Pallarés, Pérez, Morán-Navarro, & González-Badillo, 2017) incremental loading test protocol was performed, considering that recent reports (Weakley *et al.*, 2021) indicated that, for an accurate measurement of kinetic and kinematic outputs during resistance training, linear transducers should be utilized. The assessment began after a specific warm up protocol used in previous research (Pareja-Blanco et al., 2020). The participants performed the SQ from an upright position, descending at a controlled velocity until the thighs surpassed the horizontal plane, with the barbell resting freely on the upper part of the back. The participants were instructed to perform concentric actions at maximal intended velocity and were not allowed to jump or take the bar off of the shoulders. The initial load in the SQ was set at 20-kg (*i.e.*, using only the barbell as external resistance) and gradually increased by 5–10 kg. Three repetitions were performed with each load with a 3-min rest interval between sets, with the exception of the last two loads (loads $< 0.80\,\text{m} \cdot \text{s}^{-1}$) in which a single repetition was completed. The test concluded when participants reached a MPV of $\sim 0.6\,m \cdot s^{-1}$ (*i.e.*, $\sim$80%1RM). Once the assessment was finalized, three variables were used for further analysis: i) 1RM-SQ, estimated from the velocity attained with the heaviest load using the following formula (Pareja-Blanco *et al.*, 2020): $\%\ 1RM = -42.196 \cdot MPV^2 - 31.018 \cdot MPV + 112.937$; ii) 1RM-SQ relative to BM (SQ_{rel}); and iii) loads at $1\,m \cdot s^{-1}$ ($V1_{LOAD}$), which were obtained following the recommendations provided elsewhere (Elsworthy *et al.*, 2021). Of note, $V1_{LOAD}$ was chosen because it has been previously used to assess strength performance in highly trained athletes and it has also been associated to technical qualities (*i.e.*, throwing velocity) in handball athletes of different age categories (Ortega-Becerra, Pareja-Blanco, Jiménez-Reyes, Cuadrado-Peñafiel, & González-Badillo, 2018).

2.3.3 Countermovement jump

Before the measurement, participants performed a specific warm-up protocol, which consisted of 5-min of joint mobilisation exercises, including BM lunges and squats, and finally two sets of ~6 repetitions of submaximal CMJs. Afterwards, they performed three repetitions of CMJ on a contact platform (Optojump, Microgate, Italy) with 1-min of recovery between each repetition (Villaseca-Vicuña *et al.*, 2021). The CMJ started with players placing both hands on their hips and performed a countermovement to approximately 90° of knee flexion before immediately extending into a maximal vertical jump. In addition, participants were verbally instructed to jump and land on the same spot, and to land with legs extended (*i.e.*, ankles in plantar flexion, knees and hips extended), and to look ahead at a fixed point at all times. The best jump height was recorded and used for further analysis. The ICC and CV were 0.96 and 4.0%, respectively.

2.3.4 Linear and curve sprint test

For the linear sprints, participants performed two 30-m sprints on a football pitch (artificial turf), with a 3-min recovery between trials. The specific warm-up protocol consisted of multidirectional displacements, and progressive 10- to 30-m sprints, with an overall duration of ~20-min (Zabaloy *et al.*, 2021). Sprint times were measured using timing gates (Microgate-Witty Systems, Italy) placed at 0-, 10-, 20-, 25-, and 30-m. The test started in a two-point staggered position, just behind a line 0.5-m away from the first timing gate. For each attempt, the following split-times were recorded: 0–10-m (T_{10}), 0–20-m (T_{20}), 0–25-m (T_{25}), and 0–30-m (T_{30}). In addition, previous recommendations provided by Zabaloy *et al.* (2021) were followed to estimate maximum sprinting velocity (Vmax). The lowest T_{30} was recorded for further analysis.

The CS test was performed as previously described (Fílter *et al.*, 2020; Loturco *et al.*, 2020). Participants performed a CS following the trajectory of the semi-circle of the area (of an official football field according to FIFA standards), sprinting for a total distance of 17-m. Sprint times were measured using the aforementioned timing gates, which were positioned at the beginning (0-m), halfway (8.5-m, [$T_{8.5}$]), and at the end of the curved trajectory (17-m, [T_{17}]). Football players sprinted twice for each side (first to the left, then to the right), starting from a standing position 0.5-m behind the starting line. A 3-min rest interval was allowed between all attempts, and the fastest time was retained. From the best attempt of each side, the "good" ([CS_{GS}] fastest time) and "weak" ([CS_{WS}] slowest time) sides were obtained (Fílter *et al.*, 2020; Loturco *et al.*, 2020). The ICC and CV values for sprint times were > 0.90 and $< 1.84\%$ and for Vmax > 0.82 and $< 3.98\%$, respectively.

2.3.5 Aerobic fitness test

Aerobic fitness was assessed through an incremental running test performed on a treadmill, which consisted of stages of 2-min, starting from a speed of $6\,km \cdot h^{-1}$ and with speed increases of $2\,km \cdot h^{-1}$ after each stage. During the test, the slope of the treadmill was set at 1.5% (Jones & Doust, 1996). Participants were required to perform the running test until volitional exhaustion, and they were verbally encouraged to obtain the individual's maximal effort. During the test, the oxygen uptake was registered by means of an ergospirometer measurement system (Ergocard-CPX, Medisoft, España), and calibrated before each exercise test. Briefly, VO_{2max} was determined when the following ending criteria were met: (1) occurrence of a plateau in VO_2 despite an increase in speed; (2) elevated blood lactate concentration (≥ 8 mmol/L); (3) elevated R ($r \geq 1.0$); (4) elevated HR ($\geq 90\%$ of [220-age]); and (5) maximal perceived exertion (Howley, Bassett, & Welch, 1995).

2.3.6 Kicking velocity test

Kicking is a physical-technical test, which was previously used in different studies in football players (Ramirez-Campillo *et al.*, 2018; Torres-Torrelo et al., 2017). After a 10-min standardized warm-up, which briefly consisted of specific passing and kicking, subjects were instructed to perform 3 attempts using the dominant leg with full instep, with a recovery of 2-min. Specifically, subjects were instructed to strike the ball with maximal intended velocity at a circled target of 1-m diameter located in the middle of a goal. The ball was placed 8-m from the goal, and subjects were allowed to use an approach run of 1-m. If, after striking, a failure in the execution was detected (*e.g.*, not contacting with full instep or not impacting the target), the trial was considered unsuccessful, and the player was allowed to perform an additional attempt. The KV ($km \cdot h^{-1}$) was recorded by a radar gun (Supido Multisport®, Blackpool, UK) placed 1-m behind the goal according to the specific instructions provided by the manufacturer. The highest

Table 1. Differences in anthropometric and body composition measures of elite female football players across playing positions.

Variables	Playing Positions			Between Group Comparisons [*P*-values (ES ± CI 90%)]		
	Forwards	Midfielders	Defenders	Midfielders *vs.* Forwards	Defenders *vs.* Forwards	Defenders *vs.* Midfielders
Body mass (kg)	59.68 ± 6.10	61.51 ± 3.22	60.74 ± 3.32	0.462 (0.23 ± 0.55)*	0.651 (0.17 ± 0.69)*	0.588 (−0.11 ± 0.36)*
Height (cm)	160.69 ± 6.90	166.36 ± 4.72	165.58 ± 4.27	0.060 (0.62 ± 0.52)	0.252 (0.52 ± 0.79)*	0.631 (−0.12 ± 0.45)*
Σ6 Skinfolds	61.56 ± 21.36	61.44 ± 14.94	61.50 ± 20.56	0.626 (0.20 ± 0.75)*	0.848 (0.09 ± 0.85)*	0.430 (−0.24 ± 0.55)*
Fat mass (%)	24.85 ± 4.15	25.29 ± 2.14	25.89 ± 3.63	0.370 (0.31 ± 0.63)*	0.549 (0.27 ± 0.81)*	0.841 (−0.07 ± 0.61)*
Muscle mass (%)	48.91 ± 2.44	47.08 ± 1.85	47.52 ± 3.38	**0.046 (−0.75 ± 0.58)**	0.302 (−0.61 ± 1.05)*	0.496 (0.38 ± 0.99)*

Data are presented as means (± standard deviation).
*Denote unclear differences.
Bold: Denotes comparisons are significantly different.

Table 2. Descriptive results regarding physical performance measures of elite female football players across playing positions.

Variables	Playing Positions		
	Forwards	Midfielders	Defenders
KV ($km*h^{-1}$)	82.36 ± 7.13	78.22 ± 3.56	81.89 ± 3.67
CMJ (cm)	30.81 ± 4.66	25.60 ± 2.35	30.04 ± 2.52
T_{10} (s)	1.91 ± 0.07	1.98 ± 0.05	1.94 ± 0.07
T_{20} (s)	3.29 ± 0.07	3.44 ± 0.06	3.40 ± 0.29
T_{25} (s)	3.93 ± 0.09	4.19 ± 0.12	3.99 ± 0.08
T_{30} (s)	4.54 ± 0.18	4.79 ± 0.08	4.61 ± 0.09
CS $T_{8.5}$ GS (s)	1.66 ± 0.05	1.76 ± 0.12	1.64 ± 0.09
CS T_{17} GS (s)	2.96 ± 0.07	3.11 ± 0.14	2.96 ± 0.10
CS $T_{8.5}$ WS (s)	1.69 ± 0.07	1.83 ± 0.08	1.75 ± 0.09
CS T_{17} WS (s)	3.01 ± 0.07	3.20 ± 0.11	3.06 ± 0.07
VO_{2max} ($ml \cdot kg \cdot min^{-1}$)	51.57 ± 2.68	48.57 ± 5.50	46.86 ± 3.89
SQ_{rel} ($kg \cdot kg^{-1}$)	1.76 ± 0.36	1.52 ± 0.16	1.61 ± 0.14
$V1_{LOAD}$ (kg)	42.15 ± 7.54	39.48 ± 3.28	42.16 ± 5.70

Data are presented as means (± standard deviation).
Abbreviations: KV: kicking velocity; CMJ: counter movement jump; T_{10}: 10-m sprint time; T_{20}: 20-m sprint time; T_{25}: 25-m sprint time; T_{30}: 30-m sprint time; CS: curve sprint; $T_{8.5}$: 8.5-m curved sprint time; T_{17}: 17-m curved sprint time; GS and WS: good and weak side. VO_{2max}: maximum oxygen consumption; 1RM SQ: 1 repetition maximum in the squat exercise. SQ_{rel}: 1RM relative to body mass; $V1_{LOAD}$: $1\ m \cdot s^{-1}$ load in the squat.

value was retained for further analysis. Of note, low cost radar guns were reported as valid and highly sensitive tools for measuring ball velocity (Hernández-Belmonte & Sánchez-Pay, 2021), whereas in the present study, the ICC and CV were 0.82 and 3.6%, respectively.

2.4 Statistical analysis

Data are presented as the mean values and standard deviation (±SD). The distribution of each variable was verified by the Shapiro–Wilk test. Test-retest reliability was measured by the CV and ICC following a one-way random effects model. A One-way analysis of variance (ANOVA) was used to compare anthropometrical and physical characteristics between each playing position with Bonferroni's *post-hoc* comparisons. Additionally, the differences were further analysed based on Cohen's "d" Effect Size (ES) along with its 90% confidence interval (CI). Threshold values for Cohen's ES statistics were: ≥ 0.2 small, ≥ 0.6 moderate, ≥ 1.2 large, ≥ 2.0 very-large, and ≥ 4.0 nearly-perfect (Hopkins, Marshall, Batterham, & Hanin, 2009). Effects were considered unclear if the 90% confidence intervals included both substantial (< 0.2) positive and negative values (Hopkins *et al.*, 2009). Relationships between variables were determined using Pearson's correlations (r) or Spearman (rho) for the case of non-normality. The r values were interpreted as weak (≤ 0.39), moderate (0.40–0.69), or strong (≥ 0.70) (Cohen, 2013). Statistical significance was established at the $P \leq 0.05$ level. SPSS (version 24.0, SPSS Inc., IL, USA) for Microsoft Windows was used for the analysis.

3 Results

Table 1 reports the differences in anthropometric and body composition parameters between playing positions. No significant differences were observed among defenders, midfielders, and forwards in any of the reported variables

Table 3. Differences in physical performance measures of elite female football players across playing positions.

Variables	Between Group Comparisons [p-values (ES ± CI 90%)]		
	Midfielders *vs.* Forwards	Defenders *vs.* Forwards	Defenders *vs.* Midfielders
KV (km*h^{-1})	0.216 (−0.55 ± 0.78)*	0.873 (0.06 ± 0.69)*	0.105 (0.46 ± 0.47)
CMJ (cm)	**0.014 (−1.10 ± 0.66)**	0.670 (−0.11 ± 0.48)*	**0.002 (0.98 ± 0.43)**
T_{10} (s)	**0.049 (0.91 ± 0.73)**	0.406 (0.47 ± 1.01)*	0.163 (−0.53 ± 0.65)
T_{20} (s)	**< 0.001 (1.83 ± 0.71)**	0.301 (1.38 ± 2.35)*	0.564 (−0.60 ± 1.87)*
T_{25} (s)	**0.006 (2.40 ± 1.18)**	0.171 (0.68 ± 0.84)	**0.007 (−1.76 ± 0.93)**
T_{30} (s)	**0.004 (1.21 ± 0.54)**	0.259 (0.44 ± 0.68)*	**0.004 (−0.89 ± 0.43)**
CS $T_{8.5}$ GS (s)	0.089 (1.22 ± 1.18)	0.905 (−0.08 ± 1.28)*	0.106 (−1.83 ± 1.17)
CS T_{17} GS (s)	**0.045 (1.39 ± 1.08)**	0.718 (0.22 ± 1.10)*	0.095 (−1.81 ± 1.78)
CS $T_{8.5}$ WS (s)	**0.023 (1.52 ± 1.00)**	0.257 (0.85 ± 1.30)*	0.157 (−0.93 ± 1.11)
CS T_{17} WS (s)	**< 0.001 (1.96 ± 0.77)**	0.202 (0.77 ± 1.04)*	**0.027 (−1.63 ± 1.13)**
VO_{2max} (ml · kg · min^{-1})	0.152 (−1.86 ± 2.29)	**0.036 (−2.84 ± 1.85)**	0.405 (−0.57 ± 1.24)
SQ_{rel} (kg · kg^{-1})	0.076 (−0.64 ± 0.58)	0.224 (−0.41 ± 0.58)	0.096 (0.27 ± 0.27)
$V1_{LOAD}$ (kg)	0.258 (−0.32 ± 0.49)	0.837 (−0.09 ± 0.79)*	0.174 (0.29 ± 0.37)

*Denote unclear differences.
Bold: Denotes comparisons are significantly different.
Abbreviations: ES: Cohen's effect size; CI: confidence interval; KV: kicking velocity; CMJ: counter movement jump; T_{10}: 10-m sprint time; T_{20}: 20-m sprint time; T_{25}: 25-m sprint time; T_{30}: 30-m sprint time; CS: Curve sprint; $T_{8.5}$: 8.5-m curved sprint time; T_{17}: 17-m curved sprint time; GS and WS: good and weak side. VO_{2max}: maximum oxygen consumption; 1RM SQ: 1 repetition maximum in the squat exercise; SQ_{rel}: 1RM relative to body mass; $V1_{LOAD}$: 1 m · s^{-1} load in the squat.

Table 4. Pearson's correlation (r) between kicking velocity, body composition, vertical jump, linear and curved sprint performance, and different strength-derived variables in elite female football players.

	Kicking velocity	
Variables	Pearson (r)	P-value
Thigh	−0.186	0.383
Calf	0.206	0.334
FM	−0.033	0.879
MM	0.222	0.297
CMJ	0.277	0.180
T_{30}	**−0.450**	**0.024**
CS T_{17} GS	**−0.466**	**0.019**
CS T_{17} WS	**−0.573**	**0.003**
VO_{2max}	0.109	0.702
1RM SQ	0.274	0.186
SQ_{rel}	0.120	0.568
$V1_{LOAD}$	**0.508**	**0.010**

Bold: Denotes significant correlations.
Abbreviations: FM and LM: fat and muscle mass; CMJ: countermovement jump; T_{30}: 30-m sprint time; Vmax: linear sprint maximum velocity; CS: curve sprint; T_{17}: 17-m curved sprint time; GS and WS: good and weak side; VO_{2max}: maximum oxygen consumption; 1RM SQ: 1 repetition maximum in the squat; SQ_{rel}: 1RM relative to body mass; $V1_{LOAD}$: 1 m · s^{-1} load in the squat.

($P>0.05$) except for MM (%), which was significantly greater for forwards compared to midfielders ($P = 0.046$, ES = 0.76). The descriptive results with regards to the physical performance in the different playing positions are depicted in Table 2. Likewise, Table 3 reports the differences in physical performance among playing positions. Defenders and forwards showed significantly greater CMJ height, linear and CS sprint times compared to midfielders ($P < 0.001$ to 0.045), whereas forwards displayed significantly higher VO_{2max} values than defenders ($P = 0.036$).

Table 4 shows the correlation coefficients between KV, body composition, and the physical performance variables. Linear and CS performance ($P < 0.05$, $r = -0.450$ to -0.573) and $V1_{LOAD}$ ($P < 0.05$, $r = 0.508$) were significantly correlated to KV. Table 5 depicts the correlations

Table 5. Pearson's correlation (r) between linear and curved sprint performance variables in elite female football players.

	T_{10}	T_{30}	Vmax	CS $T_{8.5}$ GS	CS T_{17} GS	CS $T_{8.5}$ WS
T_{30}	**r = 0.552** **P = 0.002**					
CS $T_{8.5}$ GS	**r = 0.396** **P = 0.045**	**r = 0.456** **P = 0.019**	**r = −0.520** **P = 0.005**			
CS T_{17} GS	**r = 0.443** **P = 0.018**	**r = 0.649** **P < 0.001**	**r = −0.594** **P < 0.001**	**r = 0.916** **P < 0.001**		
CS $T_{8.5}$ WS	**r = 0.586** **P = 0.002**	**r = 0.695** **P < 0.001**	**r = −0.445** **P = 0.023**	**r = 0.528** **P = 0.006**	**r = 0.534** **P = 0.003**	
CS T_{17} WS	**r = 0.556** **P = 0.006**	**r = 0.722** **P < 0.001**	**r = −0.585** **P < 0.001**	**r = 0.752** **P < 0.001**	**r = 0.873** **P < 0.001**	**r = 0.802** **P < 0.001**

Bold: Denotes correlations are significant.
Abbreviations: T_{10}: 10-m sprint time; T_{30}: 30-m sprint time; Vmax: linear sprint maximum velocity; CS: curve sprint; $T_{8.5}$: 8.5-m curved sprint time; T_{17}: 17-m curved sprint time; GS and WS: good and weak side.

between linear and CS performance. Significant correlations were found between both tests for all assessed distances ($P < 0.05$, $r = 0.396$ to 0.916).

4 Discussion

The aims of this study were to compare anthropometric, body composition, and physical performance variables between playing positions in elite female football players and to examine the associations between KV, body composition, and a range of strength- and speed-related variables. Additionally, the correlations between linear sprint and CS performance were assessed. Overall, our findings indicated that physical performance was superior in defenders and forwards (compared to midfielders), especially in terms of sprinting and jumping abilities. Moreover, KV was significantly related to linear sprint and CS performance and $V1_{LOAD}$ at different levels of correlation. Lastly, moderate to strong relationships were observed between linear and CS times, for both "weak" and "good" sides. Our findings may have important implications for training and testing purposes, providing coaches who work in football with new information regarding the physical performance of professional female players.

In relation to the anthropometric, body composition, and certain performance variables (*i.e.*, jump height, sprint time, strength, and aerobic fitness), the present study reports important differences between playing positions which, to some extent, is in line with a recent review (Slimani & Nikolaidis, 2019) describing that, in male football players, every playing position has a "unique" physiological background. In terms of body composition and endurance, Slimani & Nikolaidis (2019) revealed that elite level midfielders had lower %FM and higher VO_{2max} than other positional roles (including goalkeepers). Notably, although we did not observe any differences in most body composition variables (*i.e.*, BM, $\sum$6SF, %FM; Tab. 1), %MM was moderately lower ($P = 0.046$) in midfielders compared to forwards, and VO_{2max} was higher in the latter compared to defenders ($P = 0.036$). To some extent, this might be caused by the specific match demands of each playing position, which depend on multiple contextual factors (*e.g.*, tactical system and technical tasks) (Baptista, Johansen, Figueiredo, Rebelo, & Pettersen, 2019). In agreement with our data, Brahim, Bougatfa, & Mohamed (2013) showed that midfielders performed worse than defenders and forwards in vertical jump tests. Moreover, in accordance with our findings, previous studies (Slimani & Nikolaidis, 2019; Villaseca-Vicuña *et al.*, 2021) reported that forwards are generally faster than defenders and midfielders over different sprint distances. Importantly, this is the first study to analyze the differences in CS ability across playing positions, confirming that midfielders are significantly slower than forwards and defenders over both linear and curvilinear trajectories. Therefore, our results support some match-play observations, indicating that midfielders usually achieve lower sprint speeds for shorter distances in comparison to defenders and forwards (Vescovi, 2012). Regarding strength capacity, non-significant ($P = 0.067$–0.096) but small-to-moderate lower values were observed in 1RM SQ and SQ_{rel} in midfielders compared to the other positions. Nonetheless, a larger sample size is required to confirm the present findings.

Analyzing the correlations, KV was moderately associated with both linear and CS sprint times ($r = -0.450$ to -0.571) and $V1_{LOAD}$ ($r = 0.508$), indicating that faster and stronger players may reach higher KV, which is compatible with their superior speed and strength levels (Cabri, De Proft, Dufour, & Clarys, 1987; Luhtanen, 1987; Torreblanca-Martínez *et al.*, 2018). To our knowledge, this is the first study to find significant correlations between KV and a number of performance measures in elite female football players. Previous research (García-Pinillos, Ruiz-Ariza, Navarro-Martínez, & Latorre-Román, 2014; Juárez-Santos-García, López-de-Subijana, Mallo-Sainz, & Navarro-Cabello, 2010; Tomáš, František, Lucia, & Jaroslav, 2014) found no significant relationships between KV, sprint speed, and vertical jump height in young football players from different levels. These contrasting results could be mainly due to age and sex (young male *vs.* adult female) although, more recently, Torreblanca-Martínez *et al.* (2018) observed that KV was correlated to sprint, jump, and aerobic fitness in pre-adolescent football players. It appears, therefore, that our findings are in agreement with the aforementioned study and suggests that speed and strength development might be related to meaningful improvements in kicking performance. Accordingly, some studies have shown that improvements in strength following distinct resistance training programs (*i.e.*, isokinetic or “conventional” resistance training) are usually accompanied by significant increases in KV and distance (Dutta & Subramanium, 2002; Manolopoulos, Papadopoulos, Salonikidis, Katartzi, & Poluha, 2004; Reilly, Lees, Davids, & Murphy, 1988). However, these results are still inconsistent and gains in kicking performance after resistance training programs seem to be less pronounced in high-level athletes (*i.e.*, international level soccer players) (Rodríguez-Lorenzo, Fernandez-Del-Olmo, & Acero, 2016 ; Young & Rath, 2011). Thus, future studies with longitudinal designs are needed to test the causal relationships between these important physical (*i.e.*, strength, speed, and jump abilities) and technical measures (*i.e.*, KV).

We detected moderate to strong relationships between linear and CS sprint times, which is consistent with previous research on both male and female football players from different levels and age-categories (Filter-Ruger *et al.*, 2022; Fílter *et al.*, 2020; Kobal *et al.*, 2021; Loturco *et al.*, 2020). Interestingly, to date, no studies have analyzed the correlations between the acceleration phase (*i.e.*, 8.5-m) of a CS and other linear and CS performance measures. In female football players, the acceleration phase of a CS on both sides is significantly associated with the acceleration phase (*i.e.*, T_{10}) of a linear sprint (Table 5). Additionally, moderate to strong correlations were identified between the time to complete a 17-m CS_{GS} and CS_{WS} and a 30-m linear sprint test (T30, $r = 0.649$ to 0.722; and Vmax, $r = -0.585$ to -0.594). The present results reinforce the findings that fastest players in linear sprinting tend to be faster in curvilinear trajectories, on both sides (Filter-Ruger *et al.*, 2022; Kobal *et al.*, 2021; Loturco *et al.*, 2020). Furthermore, our data extend these observations, revealing that these relationships are maintained even during the maximum acceleration phase, where large variations in sprint speed are expected (Loturco *et al.*, 2019). From an applied perspective, this indicates that these high-level female football players can effectively use their linear sprint speed while sprinting over curved paths, mainly due to a superior ability to cope with high (and progressively increasing) centripetal forces over different phases of CS running (Chang & Kram, 2007; Churchill, Salo, & Trewartha, 2015; Kobal *et al.*, 2021). Despite these close correlations, it is essential to emphasize that linear and curvilinear sprint abilities are not “identical” and given the key importance of CS performance in soccer, coaches are encouraged to assess and train this speed-related capability independently (Fílter *et al.*, 2020; Loturco *et al.*, 2020).

This study is inherently limited by its cross-sectional design, thus preventing better understanding of the effects of distinct training strategies and positional roles on the differences observed here. Furthermore, this precludes any causal conclusions on the reported correlations (*e.g.*, the actual effects of strength- or speed-related training on KV). Nevertheless, this is the first study to simultaneously examine the differences in CS ability across playing positions and analyze the correlations between a number of performance measures and KV in female football players. Therefore, this opens new avenues of research in professional football. In addition, body composition variables were obtained using the $\sum$6SF measures, which are, to the authors' knowledge, not the gold standard. Lastly, despite the fact that these players are subjected to daily questionnaires related to the symptoms of the menstrual cycle, these variables have not been considered in the present study. Hence, future research should consider the inclusion of the menstrual cycle effects in elite female athletes' physical performance.

4.1 Practical applications

Elite female football players (at least from this international team) of distinct playing positions (*i.e.*, forwards, midfielders, and defenders) differed significantly in a number of anthropometric and physical performance parameters. This indicates that more tailored (and position-specific) training strategies may be beneficial for optimizing the physical and technical qualities in these players. Likewise, the implementation of training practices aimed at developing strength- and speed-related capacities (including CS) might also be useful and effective to simultaneously improve their technical skills (*e.g.*, KV). These suggestions are supported by the moderate and strong correlations reported here and should be confirmed in longitudinal studies.

5 Conclusions

Overall, in elite female football players from this international team, physical performance is superior in defenders and forwards compared to midfielders, especially in terms of sprint and jump abilities. Furthermore, KV, $V1_{LOAD}$, linear sprint, and CS times are significantly associated, indicating that stronger and faster players are more likely to have better kicking performance.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to this article.

Authors' contribution

All authors contributed equally to the present investigation.

References

Baptista, I., Johansen, D., Figueiredo, P., Rebelo, A., & Pettersen, S.A. (2019). A comparison of match-physical demands between different tactical systems: 1-4-5-1 *vs.* 1-3-5-2. *PLoS One*, *14*, e0214952.

Boone, J., Vaeyens, R., Steyaert, A., Vanden Bossche, L., & Bourgois, J. (2012). Physical fitness of elite Belgian soccer players by player position. *Journal of Strength and Conditioning Research*, *26*(8), 2051–2057.

Brahim, M.B., Bougatfa, R., & Mohamed, A. (2013). Anthropometric and physical characteristics of Tunisians young soccer players. *Advances in Physical Education*, *03*(03), 125–130.

Cabri, J., De Proft, E., Dufour, W., & Clarys, J. (1987). The relation between muscular strength and kick performance. In: *Science and Football I. Proceedings of the First World Congress of Science and Football* (pp. 186–193), Liverpool, 13–17th April 1987. London, United Kingdom: E & FN SPON.

Caldbeck, M. (2020). *Contextual sprinting in Premier League Football*. Liverpool, UK: John Moores University.

Chang, Y.-H., & Kram, R. (2007). Limitations to maximum running speed on flat curves. *Journal of Experimental Biology*, *210*, 971–982.

Churchill, S.M., Salo, A.I.T., & Trewartha, G. (2015). The effect of the bend on technique and performance during maximal effort sprinting. *Sports Biomechanics*, *14*(1), 106–121.

Cohen, J. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences*. Routledge.

Dutta, P., & Subramanium, S. (2002). In: W. Sprinks, T. Reilly, A. Murphy (Eds.), *Science and soccer IV* (pp. 334–340) London: Taylor & Francis.

Elsworthy, N., Callaghan, D.E., Scanlan, A.T., Kertesz, A.H.M., Kean, C.O., Dascombe, B.J., & Guy, J.H. (2021). Validity and reliability of using load-velocity relationship profiles to establish back squat $1\,\mathrm{m \cdot s^{-1}}$ load. *Journal of Strength and Conditioning Research*, *35*(2), 340–346.

Eston, R.G., Rowlands, A.V., Charlesworth, S., Davies, A., & Hoppitt, T. (2005). Prediction of DXA-determined whole body fat from skinfolds: importance of including skinfolds from the thigh and calf in young, healthy men and women. *European Journal of Clinical Nutrition*, *59*(5), 695–702.

Filter-Ruger, A., Gantois, P., Henrique, R.S., Olivares-Jabalera, J., Robles-Rodríguez, J., Santalla, A., Requena, B., & Nakamura, F.Y. (2022). How does curve sprint evolve across different age-categories in soccer players? *Biology of Sport*, 53–58.

Fílter, A., Olivares, J., Santalla, A., Nakamura, F.Y., Loturco, I., & Requena, B. (2020). New curve sprint test for soccer players: Reliability and relationship with linear sprint. *Journal of Sports Sciences*, *38*(11–12), 1320–1325.

Fílter, A., Beltrán-Garrido, V., Dos'Santos, T., Romero-Rodríguez, D., Requena, B., Loturco, I., & Madruga-Parera, M. (2021). The relationship between performance and asymmetries in different multidirectional sprint tests in soccer players. *Journal of Human Kinetics*, *79*(1), 155–164.

Fitzpatrick, J.F., Linsley, A., & Musham, C. (2019). Running the curve: a preliminary investigation into curved sprinting during football match-play. *Sport Performance and Science Reports*, *1*(55), 1–3.

García-Pinillos, F., Ruiz-Ariza, A., Navarro-Martínez, A.V., & Latorre-Román, P.A. (2014). Análisis del rendimiento en salto vertical, agilidad, velocidad y velocidad de golpeo en jóvenes futbolistas: influencia de la edad. *Apunts. Medicina de l'Esport*, *49*(183), 67–73.

García-Ramos, A., Pestaña-Melero, F.L., Pérez-Castilla, A., Rojas, F.J., & Haff, G.G. (2018). Mean velocity vs. mean propulsive velocity vs. peak velocity: which variable determines bench press relative load with higher reliability? *Journal of Strength and Conditioning Research*, *32*(5), 1273–1279.

Harkness-Armstrong, A., Till, K., Datson, N., & Emmonds, S. (2021). Whole and peak physical characteristics of elite youth female soccer match-play. *Journal of Sports Sciences*, *39*(12), 1320–1329.

Hernández-Belmonte, A., & Sánchez-Pay, A. (2021). Concurrent validity, inter-unit reliability and biological variability of a low-cost pocket radar for ball velocity measurement in soccer and tennis. *Journal of Sports Sciences*, *39*(12), 1312–1319.

Holway, F.E., & Garavaglia, R. (2009). Kinanthropometry of Group I rugby players in Buenos Aires, Argentina. *Journal of Sports Sciences*, *27*(11), 1211–1220.

Hopkins, W.G., Marshall, S.W., Batterham, A.M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise*, *41*(1), 3–12.

Howley, E.T., Bassett, D.R., & Welch, H.G. (1995). Criteria for maximal oxygen uptake: review and commentary. *Medicine and Science in Sports and Exercise*, *27*(9), 1292–1301.

Jones, A.M., & Doust, J.H. (1996). A 1% treadmill grade most accurately reflects the energetic cost of outdoor running. *Journal of Sports Sciences*, *14*(4), 321–327.

Juárez-Santos-García, D., López-de-Subijana, C., Mallo-Sainz, J., & Navarro-Cabello, E. (2010). Analysis of the soccer kick and its relationship with the vertical jump in young top-class soccer players. *RICYDE Revista Internacional de Ciencias Del Deporte*, *6*(19), 128–140.

Kirkendall, D.T., & Krustrup, P. (2021). Studying professional and recreational female footballers: A bibliometric exercise. *Scandinavian Journal of Medicine & Science in Sports*, *32* (Suppl 1), 12–26.

Kobal, R., Freitas, T.T., Fílter, A., Requena, B., Barroso, R., Rossetti, M., Jorge, R.M., Carvalho, L., Pereira, L.A., & Loturco, I. (2021). Curve sprint in elite female soccer players: relationship with linear sprint and jump performance. *International Journal of Environmental Research and Public Health*, *18*(5), 1–10.

Loturco, I., Pereira, L.A., Freitas, T.T., Alcaraz, P.E., Zanetti, V., Bishop, C., & Jeffreys, I. (2019). Maximum acceleration performance of professional soccer players in linear sprints: Is there a direct connection with change-of-direction ability? *PLoS ONE*, *14*(5), 0e0216806.

Loturco, I., Pereira, L.A., Fílter, A., Olivares-Jabalera, J., Reis, V.P., Fernandes, V., Freitas, T.T., & Requena, B. (2020). Curve sprinting in soccer: relationship with linear sprints and vertical jump performance. *Biology of Sport*, *37*(3), 277–283.

Luhtanen, P. (1987). Kinematics and kinetics of maximal instep kicking in junior soccer players. In: *Science and Football I. Proceedings of the First World Congress of Science and Football* (pp. 441–448), Liverpool, 13–17th April 1987. London, United Kingdom: E & FN SPON.

Manolopoulos, E., Papadopoulos, C., Salonikidis, K., Katartzi, E., & Poluha, S. (2004). Strength training effects on physical conditioning and instep kick kinematics in young amateur soccer players during preseason. *Perceptual and Motor Skills*, *99*(2), 701–710.

Manson, S.A., Brughelli, M., & Harris, N.K. (2014). Physiological characteristics of international female soccer players. *Journal of Strength and Conditioning Research*, *28*(2), 308–318.

Ortega-Becerra, M., Pareja-Blanco, F., Jiménez-Reyes, P., Cuadrado-Peñafiel, V., & González-Badillo, J.J. (2018). Determinant factors of physical performance and specific throwing in handball players of different ages. *Journal of Strength & Conditioning Research*, *32*(6), 1778–1786.

Pareja-Blanco, F., Walker, S., & Häkkinen, K. (2020). Validity of using velocity to estimate intensity in resistance exercises in men and women. *International Journal of Sports Medicine*, *41* (14), 1047–1055.

Ramírez-Campillo, R., Burgos, C.H., Henríquez-Olguín, C., Andrade, D.C., Martínez, C., Álvarez, C., Castro-Sepúlveda, M., Marques, M.C., & Izquierdo, M. (2015). Effect of unilateral, bilateral, and combined plyometric training on explosive and endurance performance of young soccer players. *Journal of Strength and Conditioning Research*, *29*(5), 1317–1328.

Ramirez-Campillo, R., Alvarez, C., García-Pinillos, F., Sanchez-Sanchez, J., Yanci, J., Castillo, D., Loturco, I., Chaabene, H., Moran, J., & Izquierdo, M. (2018). Optimal reactive strength index: Is it an accurate variable to optimize plyometric training effects on measures of physical fitness in young soccer players? *Journal of Strength and Conditioning Research*, *32* (4), 885–893.

Reilly, T., Lees, A., Davids, K., & Murphy, W.J. (1988). Strength training and kick performance in soccer players. In: *Science and Football* (pp. 108–113). London: E & F N Spon.

Rodríguez-Lorenzo, L., Fernandez-Del-Olmo, M., & Acero, R.M. M. (2016). Strength and kicking performance in soccer: a review. *Strength and Conditioning Journal*, *38*(3), 106–116.

Sánchez-Medina, L., Pallarés, J., Pérez, C., Morán-Navarro, R., & González-Badillo, J. (2017). Estimation of relative load from bar velocity in the full back squat exercise. *Sports Medicine International Open*, *01*(02), E80–E88.

Slimani, M., & Nikolaidis, P.T. (2019). Anthropometric and physiological characteristics of male soccer players according to their competitive level, playing position and age group: a systematic review. *Journal of Sports Medicine and Physical Fitness*, *59*(1), 141–163.

Tomáš, M., František, Z., Lucia, M., & Jaroslav, T. (2014). Profile, correlation and structure of speed in youth elite soccer players. *Journal of Human Kinetics*, *40*(1), 149–159.

Torreblanca-Martínez, V., González-Jurado, J.A., & Otero-Saborido, F.M. (2018). Relationships between fitness test and kicking velocity in young soccer players. *Journal of Sports Medicine and Physical Fitness*, *58*(9), 1190–1196.

Torres-Torrelo, J., Rodríguez-Rosell, D., & González-Badillo, J. J. (2017). Light-load maximal lifting velocity full squat training program improves important physical and skill characteristics in futsal players. *Journal of Sports Sciences*, *35*(10), 967–975.

Vescovi, J.D. (2012). Sprint profile of professional female soccer players during competitive matches: Female Athletes in Motion (FAiM) study. *Journal of Sports Sciences*, *30*(12), 1259–1265.

Villaseca-Vicuña, R., Molina-Sotomayor, E., Zabaloy, S., & Gonzalez-Jurado, J.A. (2021).Anthropometric profile and physical fitness performance comparison by game position in the Chile women's senior national football team. *Applied Sciences*, *11*(5), 1–16.

Vivancos, A., Zambudio, A., Ramírez, F., Del Águila, A., Castrillón, F., & Pardo, P. (2014). OC14 Reliability and validity of a linear position transducer for strength assessment. *British Journal of Sports Medicine*, *48*(Suppl 3), A5.2–A5.

Weakley, J., Morrison, M., García-Ramos, A., Johnston, R., James, L., & Cole, M.H. (2021). The validity and reliability of commercially available resistance training monitoring devices: a systematic review. *Sports Medicine*, *51*(3), 443–502.

Young, W.B., & Rath, D.A. (2011). Enhancing foot velocity in football kicking: the role of strength training. *Journal of Strength and Conditioning Research*, *25*(2), 561–566.

Zabaloy, S., Freitas, T.T., Carlos-Vivas, J., Giráldez, J.C., Loturco, I., Pareja-Blanco, F., Gálvez González, J., & Alcaraz, P.E. (2021). Estimation of maximum sprinting speed with timing gates: greater accuracy of 5-m split times compared to 10-m splits. *Sports Biomechanics.* Ahead of print.

Cite this article as: Zabaloy S, Villaseca-Vicuña R, Giráldez J, Alcaraz PE, Filter-Ruger A, Freitas TT, & Loturco I (2022) Body composition and physical performance measures in elite female football players: differences across playing positions and associations with kicking velocity and curve sprint performance. Mov Sport Sci/Sci Mot, **117**, 47–56