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## ORIGINAL

# STRENGTH AND EXECUTION SPEED IN YOUNG WOMEN SOCCER PLAYERS

## CARACTERÍSTICAS DE FUERZA Y VELOCIDAD DE EJECUCIÓN EN MUJERES JÓVENES FUTBOLISTAS

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### ABSTRACT

The objective of this study was to characterize and compare the maximum and fast strength, anaerobic power, speed of execution and displacement according to the playing position in 59 young players divided into two categories. The methodology consisted of an assessment of body mass, height and 4 tests, explosive force (CMJ and SJ), velocity (30 m), anaerobic power (Wingate test) and maximum force

(% 1RM). The results showed the under 15 years old with the best records on most variables except for the size and mean propulsive velocity (MPV) squat. In the maximum power test pre-juvenile goalkeepers and defences line obtained the best record ( $409.11 \text{ W} \pm 86.73 \text{ W}$ ) and 1RM ( $60.58 \text{ kg} \pm 13.69 \text{ Kg}$ ) without significant differences. Finally, we found a significant interaction between the position and the game category in MPV squat,  $F_{55} = 21.41$ ;  $P = 0.021$ , eta square = 0.093 among the players of the two categories studied.

**KEYWORDS:** Strength, 1RM, female football, anaerobic power, execution speed and speed.

## RESUMEN

El objetivo de este estudio fue caracterizar y comparar la fuerza máxima y rápida, la potencia anaeróbica, la velocidad de ejecución y de desplazamiento en función de la posición de juego en 59 jóvenes futbolistas distribuidas en dos categorías. La metodología consistió en una valoración de masa corporal, talla y 4 pruebas, fuerza explosiva (CMJ Y SJ), velocidad (30 m), la potencia anaeróbica (Prueba de Wingate) y la fuerza máxima (%1RM). Los resultados mostraron a las pre-juveniles con los mejores registros en la mayoría de variables a excepción de la talla y el VMP sentadilla. En la prueba de potencia máxima las porteras y defensas pre-juveniles obtuvieron el mejor registro ( $409,11 \text{ W} \pm 86,73 \text{ W}$ ) y 1RM ( $60,58 \text{ Kg} \pm 13,69 \text{ Kg}$ ) sin diferencias significativas. Finalmente, se encontró una interacción significativa entre la posición y la categoría de juego en VMP sentadilla,  $F_{55} = 21,41$ ;  $p = 0,021$ , eta cuadrado = 0,093 entre las jugadoras de las dos categorías estudiadas.

**PALABRAS CLAVE:** Fuerza, 1RM, fútbol femenino, potencia anaeróbica, velocidad de ejecución y velocidad.

## INTRODUCTION

Female football's popularity and professionalism have increased significantly. However, studies concerning physical fitness characteristics and training regimes in Colombian female adolescents and women continue to be very scarce. Physical activity in football consists of a series of short efforts interspersed with periods of moderate and low-intensity activity and recovery breaks (Stolen et al., 2005). Consequently, female elite players complete 28% more high-intensity running and 24% more sprinting than intermediate-level players (Datson et al., 2014).

Besides technical and tactical aspects, strength, power, speed, agility and aerobic endurance are essential components of footballers' performance (Impellizzeri et al., 2008; Mujika et al., 2009). Thus, an increase in lower-body muscular strength allows for higher acceleration and speed when dribbling and changing direction or pace, which are crucial actions in football (Suleyman et al., 2010).

The speed required to perform an attack or counterattack action reveals the need of having not only fast, but also strong players. Therefore, physical conditioning in football gives great importance to developing appropriate power levels in elite as well as in youth players, the latter being the group involved in this study. The main goal of football coaches is to make footballers powerful, i.e., that they combine speed and strength adequately.

Furthermore, strength makes the difference in technical execution. A bad execution is frequently due to a lack of strength of the muscle groups that are directly and effectively involved in a sport action, instead of a lack of coordinative abilities. Among the aims of strength assessment, its importance on performance in a specific sport is noteworthy, allowing for effort characterization and being applicable to the training programme. The athletes' ability to develop high levels of strength and power is usually related to a high capacity to accelerate their own body weight and external objects that are used in various sports (Berger, 1982). Consequently, it seems logical that training this quality will increase speed in conditions that are similar to competition. Moreover, the degree of association between strength and power depends to a great extent on strength assessment and development. On the other hand, the relationship between the increase in strength by means of a training programme and the increase in speed will depend on speed specificity during the training.

Execution speed is also closely related to strength, and this association increases when the resistance to be sustained or overcome increases. Increased execution speed when developing strength will allow for higher power production, what will result in higher speed when performing a sport action (González, 1997). In regard to displacement characteristics in football and, in particular, in female football, Hewitt et al. (2007) reported that players cover a distance of 9,140 m in a match, while Scott and Drust (2007) estimated this distance to be 11,979 m. Regarding high-intensity displacements, D'Ottavio (1998) concluded that they hardly last longer than 3-4 seconds, what means a distance of 15 to 25 m. This author also noted that this type of action occurs 60 to 70 times in a match. Mohr et al. (2003) stated that a sprint action occurs every 90 seconds in a match and it lasts 2 to 4 seconds.

Currently, the increase in total distance covered is as important as the increase in the number of explosive actions performed during a match. Todd et al. (2002) stated that some of the most characteristic actions in a football match are: starting, breaking, jumping, charging, hitting, shooting and tackling, all being related to a decisive factor: strength. Lastly, a recent study that analysed female players' behaviour in international competitions reported a significant deficit in physical fitness, especially in anaerobic fitness (Andersson, Krusturup & Mohr, 2007). The assessment of the physical demands required by every playing position is essential to ensure specificity and correct identification of players' talent, especially of female players.

## AIM

To characterise and compare maximum and explosive strength, anaerobic power, execution speed and running speed based on age group and playing position in young female football players.

## MATERIAL AND METHOD

The sample consisted of 59 young female football players, divided into two age groups: under 13 (12-13 years) and under 15 (14-15 years). They all agreed voluntarily to participate in the study. Initially, a meeting with the coaches, players and parents was organised with the purpose to inform about the aims, methodology, benefits and potential risks of the study. Subsequently, given that players were minor, their parents signed an informed consent. The study was approved by the ethics committee of Santo Tomás University of Bogotá, Colombia. Strength and power assessment: prior to the assessment and the training program, the participants underwent a familiarisation process in which they were requested to displace different loads at maximum speed. Maximum concentric strength in half squat from a 90° angle was obtained with the 1RM method. The athletes were asked to perform the extension to 180° as fast as possible. Before the test, they completed a warm up consisting of five repetitions with loads corresponding to 40%-60% on the OMNI-RES perceived exertion scale (Robertson et al., 2003). Load was progressively increased by 10 to 20%, according to the OMNI-RES scale results, until the athlete was unable to complete the extension to 180°. Recovery time between sets was three minutes. The highest load that the athlete was able to displace under these conditions was considered her maximum strength. To determine the power-load relationship, loads of 30%, 45%, 60%, 70%, 80% and 90% 1RM were used. The players were requested to perform every movement at maximum speed. By doing so, maximum execution speed was obtained (Izquierdo et al., 2002).

Running speed was assessed by means of a 30-m test on the football field (Kotzamanidis et al., 2005). An infrared-light photocell system (Sick®, model WL34-R240; switching output: relay, SPDT; Isolated; max. switching frequency: 10/s; delay time: table, adjustable from 0.5 to 10 s.) was used to measure running speed. The photocells were placed at the beginning and end of the 30-m distance. The participants completed two types of jump: squat jump (SJ), from a position of 90° of knee flexion, and countermovement jump (CMJ), performed as fast as possible. In both cases, the athletes were asked to place their hands on their waist (Kotzamanidis et al., 2005). Optojump from Microgate® (Italy, sampling frequency: 1/1000 s) was used to determine jump height.

Lower-limb maximum power and speed were assessed by means of two protocols. The first of them was a cycloergometre test, which consisted in pedalling while seated at maximum speed for 30 seconds against a constant resistance equivalent

to 0.53% of body weight. A Monark 835E cycloergometre (Monarkexercice, Varberg, Sweden) was used after setting the saddle at the height of each participant's iliac spine. A five-minute warm up at 40 RPM and with a load of 0.30% of body weight was completed before the test. A five-second sprint was performed at minutes 2, 3 and 4. The participants performed the test after three minutes of recovery. The second protocol was a squat test that consisted of three sets of five repetitions each, with a load of 45% 1RM, with the purpose to obtain mean propulsive velocity (MPV) and maximum power. The athletes were encouraged to execute at maximum speed throughout the test. Recovery time between repetitions was five minutes.

A linear transducer (T-FORCE Dynamic Measurement System2, Ergotech Consulting S.L., Murcia, Spain; sampling frequency: 1000 Hz, accuracy: 0.0002 m) was used to assess the bar displacement speed (metres/second) and mean power (watts). This device calculates relevant kinematic parameters of every repetition automatically and provides real-time auditory and visual feedback regarding speed (Sánchez et al., 2014).

#### Statistical analysis

The software IBM SPSS version 22 (Licence of Santo Tomás University, Bogotá, Colombia) was used for statistical analysis. A descriptive analysis of every variable was conducted and the mean and standard deviation (SD) were provided for every playing position. Subsequently, a two-factor analysis of variance (ANOVA) was applied to analyse every variable based on age group and playing position. Significance level was set at  $p \leq 0.05$ .

## RESULTS

Table 1 contains the results obtained for every variable, divided by playing position (position 1: goalkeepers and defenders, position 2: midfielders and forwards) and age group.

VARIABLE	Position	UNDER 13		UNDER 15	
		N	Mean ± SD	N	Mean ± SD
Age (years)	1	18	14.10±0.39	8	16.00±0.00
	2	17	14.05±0.52	16	16.06±0.25
Height (cm)	1	18	158.83±8.03	8	163.46±5.21
	2	17	157.70±5.30	16	156.17±5.73
Body mass (kg)	1	18	48.10±6.60	8	55.43±8.11
	2	17	48.14±4.61	16	54.39±5.42
30-m run (s)	1	18	5.10±0.21	8	4.75±0.16
	2	17	5.07±0.20	16	4.80±0.21
Wingate power					
Maximum (watts)	1	18	250.76±58.50	8	409.11±86.73
	2	17	252.78±58.00	16	353.20±103.67
Relative maximum (W/kg)	1	18	5.16±0.56	8	7.36±0.70
	2	17	5.23±0.99	16	6.77±0.97
Minimum (watts)	1	18	165.28±38.88	8	237.00±50.85
	2	17	165.59±32.70	16	220.38±40.66
Relative minimum (W/kg)	1	18	3.41±0.54	8	4.25±0.45
	2	17	3.42±0.48	16	4.06±0.69
Countermovement jump (cm)	1	18	24.74±3.31	8	25.86±2.94
	2	17	23.48±4.28	16	25.49±3.90
Squat jump (cm)	1	18	21.21±2.39	8	24.66±2.98
	2	17	20.67±4.47	16	24.27±3.39
Squat power (watts)	1	18	202.06±41.18	8	225.50±42.78
	2	17	191.47±45.24	16	216.56±59.31
Squat MPV (m/s)	1	18	0.85±0.04	8	0.80±0.12
	2	17	0.86±0.06	16	0.71±0.09
Load at MPV (kg)	1	18	24.23±4.71	8	28.95±4.21
	2	17	22.87±5.31	16	31.15±10.80
1RM (kg)	1	18	31.16±5.11	8	60.58±13.69
	2	17	29.04±5.09	16	57.20±11.98

**Table 1.** Results according to playing position and age group.

Table 2 shows the results obtained for every variable, according to age group and playing position.

Variable	Factor	F-Ratio	Partial eta squared	p value	Variable	F-Ratio	Partial eta squared	p value
Age	Playing position	0.009	0	0.926	Wingate maximum power	1.62	0.029	0.208
	Age group	347.429	0.863	<0.01		37.43	0.405	<0.01
	Interaction	0.254	0.005	0.616		1.876	0.033	0.176
Body weight	Playing position	0.092	0.002	0.762	Relative maximum power	1.02	0.021	0.278
	Age group	16.93	0.235	<0.01		65.2	0.542	<0.01
	Interaction	0.106	0.002	0.746		2.016	0.035	0.161
Height	Playing position	5.78	0.095	0.02	Wingate RPM after 5 seconds	0.749	0.013	0.391
	Age group	0.784	0.014	0.38		0.648	0.012	0.424
	Interaction	3.1	0.053	0.084		0.001	0	0.982
30-m run	Playing position	0.055	0.01	0.815	Wingate minimum power	0.566	0.01	0.455
	Age group	29.39	0.348	<0.01		34.015	0.382	<0.01
	Interaction	0.46	0.008	0.499		0.61	0.011	0.438
Countermovement jump	Playing position	0.625	0.011	0.433	Wingate relative minimum power	0.377	0.007	0.542
	Age group	2.308	0.04	0.134		22.705	0.292	<0.01
	Interaction	0.186	0.003	0.668		0.427	0.008	0.516
Squat jump	Playing position	0.243	0.004	0.624	Squat MPV	2.844	0.049	0.097
	Age group	13.855	0.201	<0.01		21.416	0.28	<0.01
	Interaction	0.083	0	0.934		0.021	0.093	0.021
1RM	Playing position	1.274	0.023	0.264	Load at MPV	0.048	0.001	0.828
	Age group	139.609	0.717	<0.01		11.375	0.171	0.001
	Interaction	0.067	0.001	0.797		0.853	0.015	0.36

**Table 2.** Results according to age group, playing position and their interaction.

Significant differences between age groups were found in most of the tests conducted. A noteworthy significant difference was obtained in the speed test (30-m run) between under-13 and under-15 players ( $F_{55} = 29.39$ ,  $p < 0.01$ , partial eta squared = 0.348).

By contrast, there was no significant difference in the countermovement jump test between under-13 and under-15 players ( $F_{55} = 2.30$ ,  $p = 0.13$ , partial eta squared = 0.04).

Regarding playing position, there was a significant difference in body height between goalkeepers-defenders and midfielders-forwards ( $F_{55} = 5.78$ ,  $p = 0.02$ , partial eta squared = 0.095).

No significant difference was found in body mass according to playing position ( $F_{55} = 0.092$ ,  $p = 0.76$ , partial eta squared = 0.002).

The results yielded significant interaction between playing position and age group in squat MPV ( $F_{55} = 21.41$ ,  $p = 0.021$ , partial eta squared = 0.093).

## DISCUSSION

The number of studies found in the literature regarding male athletes' physical characteristics and performance is much larger than those concerning their female counterparts (Vescovi et al., 2011; Mujika et al., 2009). Most of these studies involved adult female elite players, whose characteristics differed from those of the present study's participants. However, some studies involving female football players of a wide age range were found, some of which included the age groups and variables analysed in this study.

Firstly, Manson et al. (2014) analysed 52 young New Zealander female football players, from 14 to 36 years old, divided into three age groups. The authors reported a height and body mass of 164 cm ( $\pm 5.15$  cm) and 58.0 kg ( $\pm 5.48$  kg), respectively, for the under-17 group (14-17 years). These values were very similar to those obtained in the present study for the under-15 group.

Sander et al. (2013) studied 134 German female elite players between 15 and 19 years old, divided into three age groups. They reported a height of 155.9 cm and a body mass of 46.4 kg for the under-15 group (13-15 years), both values being lower than the ones obtained in the present study. These values were taken at the beginning of the aforementioned study, which lasted two years.

Nicolao et al. (2010) conducted a study with 36 Brazilian players between 12 and 15 years old, with the aim to assess the effect of sexual maturation on the lactate threshold in female football players. At the age of 13.17 years ( $\pm 1.16$  years), they reported 49.33 kg ( $\pm 7.47$  kg) of body mass and 155.67 cm ( $\pm 5.01$  cm) of height. These results were very similar to those obtained for the under-13 group in the present study.

A large number of studies in the literature involving female football players include a running speed test (Spencer et al., 2005; Polman et al., 2004; Vescovi & McGuigan, 2008). Nevertheless, the use of different assessing protocols makes it difficult to compare the results. The most used test is the 20-m run test, where the Australian national team ran 3.31 s ( $\pm 0.11$  s) (Tumilty & Darby, 1992).

Little information is available on speed differences based on playing position. Vescovi et al. (2011) assessed several speed variables (10 to 40-yard sprints) and concluded that there was no significant difference among playing positions, although the defenders tended to be slower. This was true in the present study's



under-13 group, where goalkeepers and defenders were slower; however, the opposite was found in the under-15 group.

Explosive strength is the physical capacity that was most frequently assessed in the literature. Vescovi et al. (2011) analysed 414 North American female adolescents between 12 and 21 years old, divided into ten groups, one per year of age. Explosive strength was assessed by means of the countermovement jump. Jump height increased with age until 16 years old, while no significant improvements were detected from this age until 21 years old. Jump height at the ages of 12 and 13 was 37.4 cm, much higher than in the present study (24.6 cm).

Similarly, the study by Haugen et al. (2012) involved 194 Norwegian elite women from 15 to 35 years old. The authors analysed speed (40-m run test) and CMJ height depending on playing position. Participants under 18 years old reached 27.9 cm in the CMJ test and 5.77 s in the 40-m run test, the former being higher and the latter being lower than the results of the present study. Nonetheless, it must be noted that the running speed test conducted in our study was 30-m long and the participants ranged between 12 and 14 years old. Regarding playing position, forwards achieved the best results in the running speed and CMJ tests.

Sander et al. (2013) took a sample of 134 German female elite players between 15 and 19 years old, divided into three age groups. They completed their usual football training plus one strength training session per week for two years. This combination led to improvements in maximum strength and 30-m speed. The 30-m time was 4.87 s in the under-15 group, very similar to the present study (4.75 s).

In South America, Frazilli et al. (2010) assessed SJ and CMJ height in young Brazilian players divided into two groups: under 15 (14-15 years) and under 17 (16-17 years). The younger group jumped  $32.38 \pm 4.12$  cm in SJ and  $35.56 \pm 3.93$  cm in CMJ, these results being 8 to 11 cm higher than the values registered in the present study for the under-13 group. These authors conducted a 20-m running speed test, obtaining a mean value of 3 s.

A number of studies were found which involved adult female football players between 18 and 21 years old and took playing position into account. Within this group, Izquierdo et al. (2008) analysed 42 Spanish first-division female footballers, not obtaining significant differences among playing positions as regards explosive strength. It is noteworthy that goalkeepers achieved very low values, compared with the rest of playing positions. This is in contrast to our study, where goalkeepers and defenders showed the best results in most of the analysed variables.

Lastly, Pantelis et al. (2014) measured mean, maximum and peak power of 54 Greek female players of different playing positions by means of the Wingate test. The peak power values for goalkeepers, midfielders, defenders and forwards were, respectively,  $658 \pm 29$  W,  $577 \pm 78$  W,  $570 \pm 63$  W and  $571 \pm 85$  W.

To the authors' knowledge, there was only one similar study conducted in Colombia (Méndez et al., 2007). The authors assessed explosive strength by means of SJ and CMJ and running speed with a 20-m test in young men ranging between 14 and 20 years old. Their main purpose was to compare two training methods, using 85% and 75% 1RM, respectively, to improve muscle power. Therefore, the present study is the first one conducted in Colombia with female participants to analyse the mentioned variables.

## **CONCLUSION**

- 1- In regard to the first general aim established in this study, significant differences between age groups and playing positions were found in most of the variables analysed, except in CMJ height, RPM after 5 s and load at MPV. This suggests that these variables are not sensitive indicators to distinguish between the factors used in this study.
- 2- The results revealed very little differences between playing positions. Only goalkeepers and defenders seemed to have physical fitness characteristics that were specific to the technical demands of their playing position. Besides, their results in most of the analysed variables were better than those of the other playing positions.

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