



## Role of Vertical Jumps and Anthropometric Variables in Maximal Kicking Ball Velocities in Elite Soccer Players

by

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*Kicking is one of the most important skills in soccer and the ability to achieve maximal kicking velocity with both legs leads to an advantage for the soccer player. This study examined the relationship between kicking ball velocity with both legs using anthropometric measurements and vertical jumps (a squat jump (SJ); a countermovement jump without (CMJ) and with the arm swing (CMJA) and a reactive jump (RJ)). Anthropometric measurements did not correlate with kicking ball velocity. Vertical jumps correlated significantly with kicking ball velocity using the dominant leg only ( $r = .47$ ,  $r = .58$ ,  $r = .44$ ,  $r = .51$ , for SJ, CMJ, CMJA and RJ, respectively). Maximal kicking velocity with the dominant leg was significantly higher than with the non-dominant leg ( $t = 18.04$ ,  $p < 0.001$ ). Our results suggest that vertical jumps may be an optimal test to assess neuromuscular skills involved in kicking at maximal speed. Lack of the relationship between vertical jumps and kicking velocity with the non-dominant leg may reflect a difficulty to exhibit the neuromuscular skills during dominant leg kicking.*

**Key words:** kicking performance, jumping performance, strength, dominant leg, non-dominant leg, kicking deficit.

### Introduction

Soccer is one of the most popular sports in the world with 265 million players worldwide (FIFA, 2007). Different studies have investigated match skills in soccer (Lees et al., 1998; Masuda et al., 2005).

Kicking is the most widely studied soccer skill (De Proft et al., 1988; Masuda et al., 2005; Rodríguez-Lorenzo et al., 2015), as it is one of the most important skills in soccer (Bacvarevic et al., 2012; Barfield et al., 2002). Moreover, kicking is the most used and determinant skill in competition (Kellis and Katis, 2007; Sedano et al., 2009).

The performance of soccer kicking usually depends on kicking ball velocity and accuracy (Lees and Noland, 1998). Although, accuracy is an important factor, kicking performance in soccer has been evaluated predominantly by maximum ball velocity (Markovic et al., 2006). Therefore,

when a soccer player performs an accurate kick towards an area of difficult interception by the goalkeeper, the chance of scoring increases with an increased ball velocity since there is less time for the goalkeeper to react (Markovic et al., 2006). In addition, it has been shown that the most successful goal scorers are those players who are able to score with both legs (Starosta, 1988). Therefore, the ability to kick with both legs leads to an advantage for the soccer player. However, the majority of the players have a slower maximal ball velocity when they kick with the non-dominant leg in comparison with the dominant leg (Barfield, 1995; Barfield et al., 2002; Dörge et al., 2002; Nunome et al., 2006a).

Several studies have been conducted in order to explore different factors that could affect maximal kicking velocity (Rodríguez-Lorenzo et al., 2015). Maximum kicking velocity is a complex

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skill that depends on technical (Juárez et al., 2010; Nunome et al., 2006b), biomechanical (Young and Rath, 2011), physiological (Ferraz et al., 2012), neuromuscular (Dörge et al., 1999; Kristensen et al., 1996; Nunome et al., 2006a) and strength factors (Masuda et al., 2005). In addition, anthropometric measurements have been studied in the context of potential use for the selection and future development of young soccer players (Helsen et al., 2005; Wong et al., 2009). Although, a positive relationship has been found between kicking performance and anthropometric measurements (Alessandro et al., 2014; Luhtanen, 1988), no studies have been conducted with adult elite soccer players. Therefore, it remains unknown whether the anthropometric variables are related with kicking performance once the players complete their physical growth. Improvement in maximal kicking velocity may be mediated by any one of the above mentioned factors. For instance, an increase in maximum kicking velocity performance may be attributed to an improvement in strength and explosiveness of the leg extensor muscles (Maulder and Cronin, 2005). However, the relationship between strength measurements and kicking performance is a subject of controversy (Young and Rath, 2011).

One way to determine the potential importance of the function of various muscles is to identify the relationship between strength measures and maximum ball velocity (Young and Rath, 2011). Some investigators reported positive and significant correlations between isokinetic strength and maximum kicking velocity (Luhtanen, 1988; Masuda et al., 2005). However, other studies did not find that relationship (Dörge et al., 2002; McLean and Tumilty, 1993; Mognoni et al., 1994; Narici et al., 1988). Therefore, there is a lack of consistency in the relationship between isokinetic strength and maximum kicking velocity, and thus, it is not possible to establish a cause-and-effect relationship between the strength measures and kicking performance (Young and Rath, 2011).

An alternative to isokinetic tests could be vertical jump tests. Explosive strength in the form of vertical jumping has been deemed to be functional for optimal performance in soccer (Stolen et al., 2005). However, only a few studies have previously investigated the possible relationship between vertical jump variables and

maximal kicking velocity. Furthermore, the results from these studies are inconsistent. While some studies reported significant correlations between vertical jump variables and maximal kicking performance (Clark and Brooks, 2011), others found unclear (Juárez et al., 2008; Sousa et al., 2003) or non-significant correlations (Juárez et al., 2008, 2010). Moreover, these studies were conducted in students and children and thus, it remains unknown whether performance in the vertical jump is associated with maximal kicking velocity in elite soccer players and whether that relationship is similar for both the dominant and non-dominant leg.

Therefore, the goals of this study were as follows: i) to explore the relationship between vertical jumps and maximal kicking ball velocity with both legs in elite soccer players, ii) to compare the kicking performance between both legs, and iii) to explore the relationship between maximal kicking ball velocity and anthropometric measurements. This study provides further information regarding the role of strength in maximal kicking velocity, the nature of the kicking deficit of the non-dominant leg and the effect of the anthropometric features in kicking velocity.

## **Material and Methods**

### *Experimental Approach to the Problem*

Two experimental sessions were conducted on 2 days, separated by 48 hours of rest, at an ambient temperature of 16 to 18°C. Four familiarization sessions were conducted where subjects practiced maximal kicking and jump tests, in order to minimize any learning or habituation effects. For vertical jumps we followed the procedure described by Acero et al. (2011). To avoid inter-observer variability, the same experienced investigator tested all subjects.

The first experimental session started with the anthropometric measurements, followed by a warm-up which consisted of 5 min indoor running at a self-selected pace, a 5 min active stretching protocol, mainly for the lower limbs, 2 submaximal squat jumps and 2 submaximal countermovement jumps. After the warm-up, subjects were demonstrated each of the tests and performed 1 practice trial for habituation. The following 2 trials were recorded as experimental trials. Each subject had at least 3 min of rest

between 2 consecutive trials on the vertical jumps in order to avoid fatigue.

The second experimental session consisted of the maximal kick test. The session started with a warm-up consisting of 5 min indoor running at a self-selected pace, a 5 min active stretching protocol, mainly for the lower limbs, 6 submaximal and 2 maximal instep kicks performed with each leg. After warming-up the kick test was demonstrated, followed by 1 practice trial performed with each leg. The following 3 trials with both the preferred and the non-preferred leg were recorded as experimental trials. The trial that produced the highest speed for both the preferred and the non-preferred leg was selected for further analysis. The order of testing was randomized between the preferred and the non-preferred leg. Each subject had at least 1 min of rest between 2 consecutive trials to avoid fatigue.

#### **Participants**

Twenty three male elite soccer players (mean age  $20.27 \pm 4.49$  years; body mass  $71.84 \pm 6.52$  kg; body height  $177.3 \pm 5.83$  cm; body mass index  $22.84 \pm 1.2$  kg·m<sup>-2</sup>; goalkeepers  $n = 2$ , defenders  $n = 7$ , midfielders  $n = 7$ , and attackers  $n = 7$ ) from the Real Club Deportivo de la Coruña second team (3<sup>rd</sup> Spanish Division), were tested as a part of their athletic training program during the final month of the 2013-2014 competitive season (May, 2014).

At the time of the study, all players had an average of over 10 years of soccer training experience and had trained an average of 4 times, as well as one game per week for at least 4 years. Fifteen players preferred to kick with the right leg and eight preferred to kick with the left leg.

After receiving a detailed explanation of the study's benefits and risks, all participants signed informed consent and completed a form giving, personal, medical and training details. None of the subjects reported neurological diseases or recent injuries. The study was approved by the medical department of Real Club Deportivo de la Coruña (Spain). The experimental procedures of the study were carried out in accordance with the Declaration of Helsinki.

#### **Procedures**

##### *Anthropometric measurements*

A total of eleven anthropometric measurements were recorded according to the

International Society for the Advancement of Kinanthropometry's protocol (Marfell-Jones et al., 2006). All anthropometric measurements were taken twice in the right side of the body by the same trained anthropometrist in standardized order after a proper calibration of the measuring instruments.

Body mass was measured using a BFW300 Platform scale (Adam Equipment Co. Ltd., UK.) to the nearest 0.1 kg. Body stature was measured using a Harpenden stadiometer (Holtain Limited, UK.) to the nearest 0.1 cm. Lengths and breadths were measured using a Siber-Hegner Anthropometer (Zurich, Switzerland) to the nearest 0.1cm. Girths were measured using a Lufkin W606PM flexible steel tape (Cooper Industries, USA) to the nearest 0.1cm.

##### *Kicking test*

A modified version of the kicking test described by Markovic et al. (2006) was used to measure maximal ball velocity. The participants were instructed to perform an instep kick of a stationary ball of standard size and standard inflation (Fédération Internationale de Football Association, FIFA, standard) as fast as possible towards the radar gun. To standardize the procedure, the participants were restricted to a 5-step run-up from a position directly behind the ball. They were specifically instructed to focus only on maximum kicking velocity and the trials that missed the entire target area were repeated. Only 6 players needed to perform additional kicks and the maximum number of kicks performed by a player was 8.

Kicking performance was determined from maximal ball velocity. Velocity, expressed in m/s, was assessed using a stationary Doppler radar gun (Stalker Sport 2, Stalker Radar, Plano, Texas, USA) that can measure speeds between  $2.23 \text{ m}\cdot\text{s}^{-1}$  and  $67.04 \text{ m}\cdot\text{s}^{-1}$  with accuracy of  $\pm 0.045 \text{ m}\cdot\text{s}^{-1}$ . The radar gun (operating frequency of 24.125 GHz) was attached to a 0.7 m high stand and positioned behind a net, approximately 5 m from the starting position of the ball. The size of the net was sufficient to cover all kicks that deviated less than 15° from the direction of the radar gun (Markovic et al., 2006). The radar gun was always calibrated immediately before the sessions according to the instructions given in the user's manual.

### Vertical Jump Tests

The SJ and CMJ tests were performed according to the protocols described by Bosco et al. (1983). The CMJA and 1RJA tests were performed according to the protocols described by Acero et al. (2012), where a more restricted action of the arms was imposed compared with the protocols of Bosco et al. (1983).

All vertical jumps were performed on a force plate (Quattro Jump, Kistler, Winterthur, UK) in the following order: a squat jump (SJ), a countermovement jump (CMJ), a countermovement jump with the arm swing (CMJA) and a reactive jump with the arm swing (1RJA).

### Data Analyses

Anthropometric variables consisted of eleven measurements: body mass, body stature, 2 lengths (trochanterion and tibiale laterale height), 3 girths (arm flexed and tensed girth; thigh girth; calf girth), and 4 breadths (biiliocrystal; biepicondylar femur). The mean value of the 2 measurements at each site was used for the analyses.

For the kicking test average velocity, maximal velocity and the coefficient of variation (CV) from the 3 trials were calculated. In addition, a kicking deficit variable (KD) was calculated according to the following formula:

$$KD = \left( \frac{KV_{domMax} - KV_{nodomMax}}{KV_{domMax}} \right) \cdot 100$$

where  $KV_{domMax}$  and  $KV_{nodomMax}$  are the maximal velocities achieved with the dominant and non-dominant leg, respectively. The kicking deficit was defined as the percentage of the difference between maximal velocity obtained with the non-dominant leg in relation with the dominant leg.

For the vertical jump, height was calculated according to the following formula (Bosco et al., 1983):

$$SJ_H = 0.5 \cdot g \cdot \left( \frac{flight\ time}{2} \right)^2$$

where flight time was the time between the takeoff and landing.

### Statistical Analyses

Normal distribution of the variables was tested using the Shapiro-Wilk W-test. A Student's

t-test for dependent samples was performed to compare maximal kicking velocities and CVs obtained with the dominant and non-dominant leg.

In order to explore whether the kicking deficit was related to maximal kicking velocity achieved by the dominant or non-dominant leg (i.e. to test whether the players with the highest maximal kick velocity with the dominant leg also had the greatest kicking deficit), the sample was divided into two groups according to the median value of the kicking deficit velocity. A Student's t-test for independent samples was performed for  $KV_{domMax}$  and  $KV_{nodomMax}$ .

Pearson product correlation analysis was performed to assess the relationships between the kick test ( $KV_{domMax}$ ,  $KV_{nodomMax}$ ), anthropometric measurements and the vertical jumps (SJ, CMJ, CMJA, RJ).

All statistical analyses were performed using SPSS version 21 (SPSS, Chicago, IL). A  $p$  value  $< 0.05$  was considered statistically significant.

## Results

Mean and SD values of the variables are shown in Table 1. None of the data violated the normality assumption necessary to conduct parametric statistical tests.

T-test analysis revealed that maximal kicking velocity with the dominant leg ( $KV_{domMax}$ ) was significantly higher than with the non-dominant leg ( $t = 18.04$ ,  $p < 0.001$ ). No significant differences were found for the individual CV values of the kicking velocity between the legs.

There were no differences in the  $KV_{domMax}$  and  $KV_{nodomMax}$  between the groups with higher and lower kicking deficits, suggesting no relationship between maximal kicking velocity achieved by either leg and kicking velocity.

Table 2 shows the coefficients of correlation among variables. Anthropometric measurements did not correlate with kicking velocities. Maximum kicking velocities between legs correlated significantly ( $r = .75$ ,  $p < 0.01$ ).

**Table 1***Characteristics of the sample*

Dimension	Mean	SD	Minimum	Maximum
Age (years)	21.12	2.42	18.03	26.31
Body mass (kg)	71.84	6.52	61.20	86.20
Stature (cm)	177.23	5.83	167.50	189.00
Trochanterion height (cm)	90.91	4.00	83.30	99.70
Tibiale laterale height (cm)	43.92	2.63	39.50	49.20
Arm flexed and tensed girth (cm)	31.62	2.04	27.70	35.50
Thigh girth (cm)	51.04	3.84	42.50	57.60
Calf girth (cm)	36.00	2.07	30.50	39.00
Biiliocrystal breadth (cm)	28.97	1.27	26.80	31.20
Maximum velocity Dominant leg (m/s)	31.48	1.45	29.17	34.5
Maximum velocity Non-Dominant leg (m/s)	27.54	1.53	24.72	30.72
CV Average velocity Dominant leg (m/s)	1.03	0.74	0.30	3.49
CV Average velocity Non-Dominant leg (m/s)	1.36	1.19	0.03	4.82
Kicking Deficit	12.49	3.24	5.52	17.59
SJ (cm)	31.10	4.34	21.60	38.20
CMJ (cm)	33.07	3.88	23.90	38.70
CMJA (cm)	37.79	3.94	29.00	45.00
RJ (cm)	31.68	7.37	16.40	44.40

**Table 2***Correlation values between variables.*

Variables	Maximum velocity Dominant leg	Maximum velocity Non-Dominant leg
<i>Anthropometric measurements</i>		
Body mass	0.274	0.157
Stature	0.287	0.174
Trochanterion height	0.029	0.021
Tibiale laterale height	-0.099	-0.136
Arm flexed and tensed girth	0.329	0.323
Thigh girth	0.035	0.103
Calf girth	0.252	0.293
Biiliocrystal breadth	0.226	0.281
<i>Kicking test</i>		
Maximum velocity Dominant leg	-	0.754**
Maximum velocity Non-Dominant leg	0.754**	-
<i>Jump test</i>		
SJ	.475*	0.075
CMJ	.582**	0.312
CMJA	.444*	0.317
RJ	.510*	0.112

\* Correlations significant at  $p < 0.05$ ; \*\* Correlations significant at  $p < 0.01$ .

**Table 3**  
*Kicking deficit and maximal kicking velocity values for dominant and non-dominant leg performance*

Research	Subject characteristics			Kick	Kicking deficit †	RI	VB (m·s <sup>-1</sup> )	
	n	Age Instep	Player level				Dominant	Non-dominant
Narici et al. (1988)	11	25.1±5.0	Amateur		11.5	ARS	20.0 ± 3.6***	17.7± 2.2***
McLean and Tumilty (1993)	20	16.8±0.7	Elite junior	Drive kick	16.45	R	21.95±1.67*	18.34±1.39*
Mognoni et al. (1994)	24	NA	Junior		9.32		23.6±2.5	21.4±2.6
Barfield. (1995)	18	NA	Expert		7.95	R	26.4±2.1	24.3±2.0
Dörge et al. (2002)	30		Skilled		12.95	R	24.7±2.5*	21.5±2.0*
Barfield et al. (2002)	8	19-22	Élite	Instep		2C	***	***
	2		Male		6.71		25.3±1.51***	23.6±1.57***
	6		Female		12.09		21.5±2.44***	18.9±2.05***
Vaverka et al. (2003)	12	15.7±0.4	Skilled		15.14	3D	27.68±1.32	23.49±2.05
Nunome (2006a)	5	16.8±0.4	Skilled	Instep	15.58	3C	32.1±1.7*	27.1±1.2*
Sedano et al. (2009b)	10	22.8±2.1	Elite female	Pre-Trained	16.45	R	19.45±0.7*	16.25±0.45*
				Post-Trained	15.45		21.75±0.58*	18.39±0.64*
Berjan et al. (2012)	106	11.514.5	Elite young	Instep		R		
	27	12.2±0.3		Maximal	13.21		22.7±2.5*	19.7±2.3*
	26	13.1±0.2		Maximal	18.15		24.8±2.1*	20.3±2.7*
	26	14.3±0.3		Maximal	14.76		27.1±2.8*	23.1±2.9*
Barbieri et al. (2015)	27	15.3±0.3		Maximal	14.63		28.7±2.3*	24.5±3.1*
	10	21.8±2.2	Amateur futsal	Instep	10.91	3D	24.27±2.21***	21.62±2.26***

Note: n = Sample size; RI = Register instrument; R=Radars;  
 ARS = Audio recording system; C = Video camera; 3D = Motion capture system;  
 VB= Kicking ball velocity; NA= No available data;  
 Statistical significance: \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.00$ ;  
 † Kicking deficit is calculated from the total average reported by those studies

The results obtained from vertical jump tests revealed a significant and moderate relationship between maximum kicking velocity with the dominant leg and the height of each vertical jump (SJ, CMJ, CMJA, RJ). Interestingly, maximum kicking velocity with the non-dominant leg did not correlate with any vertical jump.

## Discussion

The purpose of this study was to compare

maximum kicking velocity between the dominant and non-dominant leg and their relationship with the performance of a vertical jump. The main finding of our study was that there was a significant correlation between the performance of a jump test and maximum kicking velocity with the dominant leg, while no significant relationship was found for the non-dominant leg. In addition, maximum ball velocity after a soccer kick was significantly different between the dominant and

non-dominant leg, indicating a kicking deficit with the non-dominant leg.

Ball velocity of maximal instep kicks for the dominant and non-dominant leg had been previously studied (Table 3). Ball velocity values of the dominant (mean  $31.48 \pm 1.45$  m/s) and non-dominant (mean  $27.54 \pm 1.53$  m/s) leg recorded in the present study were higher than in previous studies (mean 14.7). This may be due to the fact that our subjects were elite soccer players with at least 10 years of extensive practice.

We found a significant relationship between the height achieved in the vertical jump tests and maximum kicking velocity with the dominant leg. To the best of our knowledge only two studies had shown a significant relationship between maximal kicking velocity with the dominant leg and vertical jumps (Sousa et al., 2003). Sousa et al. (2003) reported a very weak significant relationship between kicking velocity and the SJ ( $r = .10$ ) and the CMJ ( $r = .07$ ). It is possible that the wider range of values during the vertical jumps in the Sousa's study in comparison with our study could explain the low relationship that the authors found between both variables. Nevertheless, our results contrast with previous studies that have shown no relationship between ball velocity and performance in different jump tests (Juárez et al., 2008, 2010). Several methodological issues, such as familiarization with the testing protocols or the features of the sample, may account for these differences. In our study the subjects performed four preliminary familiarization sessions of the testing procedures in order to minimize any effects of learning, achieve their maximal performance during the experimental sessions, and obtain reliable data. No familiarization sessions were conducted in previous studies (Juárez et al., 2008, 2010; Sousa et al., 2003). It is possible that the lack of familiarization sessions could increase the intra-subject variability (Acero et al., 2011), affecting the correlation analysis. In addition, the sample used in previous studies was very small, the soccer players were non-elite and under 15 years old (Juárez et al., 2008). The elite level and years of practice in the current study's sample mean that the data are reliable, as recent studies have reported that experienced players displayed less variability in the kicking pattern (Southard, 2014). In summary, it is likely that the rigorous

methodology used in our study for data acquisition together with the expertise of the soccer players contributed to the strong correlations observed between the vertical jump and kicking performances.

It is also plausible that, in the current study, the core strength training program that the soccer players performed as a part of their regular soccer training may have contributed to the performance of both the ball kick and the vertical jump and thus, enhanced the correlation between these variables. This is supported by a recent study which showed that core training improved maximum kicking velocity due to a better transfer of forces from the trunk to limb muscles (Prieske et al., 2015). In addition, performance of a vertical jump is also enhanced by trunk stability exercises (Butcher et al., 2007).

The observed correlation between the performance of the vertical jumps and ball kicking with the dominant leg suggests that both tasks share some common muscle demands, such as the ability to reach high levels of force in a short period of time. The vertical jump test could be an optimal test to assess the neuromuscular skills involved when kicking at maximal speed. This hypothesis is supported by previous studies that have reported similar improvements in kicking velocity and the height of vertical jumps after strength training programs (García-Pinillos et al., 2014; Marques et al., 2013; Sedano et al., 2009). Interestingly, no correlations were found between the vertical jumps and kicking velocity with the non-dominant leg. This lack of the relationship could be interpreted as a difficulty to utilize the neuromuscular skills required for an optimal kicking performance. Higher ball velocity can be achieved by increasing foot velocity at impact (Young and Rath, 2011), which is dependent on the neuromuscular skill and technique levels (Dörge et al., 1999; Katis and Kellis, 2010; Kellis et al., 2004; Southard, 2014). It is possible that in our players the muscular function of each leg was highly specific. While the non-dominant leg is trained to develop isometric tension (to provide a stable platform for the swing of the kicking leg), the kicking and dominant leg is characterized by an explosive action (Dörge et al., 2002; Lees and Noland, 1998; Young and Rath, 2011). This muscle specificity could be compromised during the kicking action with the non-dominant leg, which

may explain the lack of correlation with the vertical jump, a skill that requires an explosive muscle contraction.

Our results show that subjects produced significantly higher ball velocity with their preferred leg than with their non-preferred leg. Similar findings have been shown in expert soccer players (Barfield, 1995, 2002), amateurs (Marques et al., 2011; Mognoni et al., 1994; Narici et al., 1988; Vaverka, 2003), young subjects (Berjan et al., 2012), for both genders (Barfield et al., 2002; Sedano et al., 2009), for kicks with or without accuracy demand (Bacvarevic et al., 2012), and for different techniques and kicking conditions (Marques et al., 2011; McLean and Tumilty, 1993). The most straightforward explanation for these results is that the kicking technique is better with the dominant compared to non-dominant leg (Barbieri et al., 2015; Barfield et al., 2002; Teixeira, 1999; Vaverka et al., 2003). Unfortunately, in the current study we did not record the biomechanics of the kick in order to test this hypothesis. However, the coefficient of variation of the kicking performance was not significantly different between legs. It is known that the expertise of a task is related to lower variability in performance (Schmidt, 1988). Thus, it is possible that the specificity of the muscle function of each leg during kicking could be a possible reason for the difference in kicking velocity observed between dominant and non-dominant legs.

In our study the players who achieved higher ball velocities with the dominant leg, also achieved higher ball velocities with the non-dominant leg. However, when the players were divided into two groups according to the median value of the kicking deficit, there were no differences between kicking velocities with the dominant and non-dominant leg. These results suggest that the kicking deficit is independent of the absolute maximal kicking velocity of the dominant leg. In addition, the values of the kicking deficit were more variable across players compared with the values for maximal kicking velocity for both dominant and non-dominant legs. For instance, the player with the highest kicking deficit reported values threefold that of the player with the lowest deficit (17.59% vs. 5.52%, respectively). Therefore, the kicking deficit may be more helpful when evaluating and monitoring the individual capacity of each player

to perform at similar levels with both legs rather than the use of absolute maximal velocity values. This is of relevance since the ability to kick with both legs is an advantage for the soccer player (Starosta, 1988).

The correlational analysis did not show any relationship between the anthropometric measurements and kicking velocity. This is in contrast with previous findings in young soccer players that had shown a significant correlation between kicking performance and body mass (Alessandro et al., 2014; Luhtanen, 1988) or between kicking performance and stature (Luhtanen, 1988). Lack of this relationship in the current study with adult elite soccer players suggests that anthropometric characteristics may be overvalued during the process of sports training, especially during puberty. Our results are in line with Alessandro et al. (2014) who found that anthropometric characteristics did not predict match-related technical performance and concluded that anthropometric features should be used with caution for talent identification or training purposes. However, it has been reported that soccer coaches select young players based on their anthropometric characteristics rather than their technical and tactical performance (Helsen et al., 2005; Maulder and Cronin, 2005). Such procedures could provide short-term benefits in soccer team performance, but may prevent the long-term development of young soccer players, since once players complete their physical growth value of the anthropometric advantages decreases and technical and tactical factors become significantly more important. Therefore, as suggested by Reilly et al. (2000) and Wong et al. (2009), psychological and soccer-specific skills should also be considered in the selection of young soccer players.

Our study has several limitations. The players were from a single soccer team and participated in the 3<sup>rd</sup> Spanish Division, thus, extrapolation of our findings to other teams and soccer player's levels must be done with caution. In addition, the tests were conducted at the end of the competitive season and thus, it remains to be explored whether the relationships between variables found in the current study are consistent throughout the competitive season. Therefore, futures studies must address those questions in order to further understand the relationship

between vertical jumps, anthropometric variables and maximal kicking ball performance.

Nevertheless, and from a practical point of view, the current study suggests that the kicking deficit variable may be useful for coaches when evaluating and monitoring the individual player's capacity to perform at similar levels with both legs rather than the use of the absolute maximal velocity. Finally, lack of a relationship between anthropometric variables and kicking performance supports the hypothesis that the anthropometric characteristics should not be overvalued by coaches during training and the selection process of soccer players.

## Conclusions

In summary, our results show a positive relationship between the performance of vertical jumps and the dominant leg maximal kicking velocity. This suggests that vertical jumps may be an optimal test to assess the neuromuscular skills involved in kicking at maximal speed. This relationship was absent for the non-dominant leg and may be interpreted as a difficulty to utilize the neuromuscular skills required for an optimal kicking performance. Furthermore, our findings show that the kicking deficit exhibited by the non-dominant leg is independent of the absolute maximal kicking velocities of the dominant leg.

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