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# ORIGINAL

# AGE-RELATED DIFFERENCES IN KICKING PERFORMANCE IN SOCCER

# DIFERENCIAS DE EDAD EN EL RENDIMIENTO DE GOLPEO DE BALÓN EN FÚTBOL

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## ABSTRACT

The purpose of this current study was to examine the age-related differences in kicking performance with both legs in 175 youth soccer players. Players from the development programme of a professional club were grouped according to their respective under-age team (U-9 to U-18), in addition to the club's second team (U-23). Maximal kicking velocity with the preferred and non-preferred leg was recorded using a Doppler radar gun. Kicking deficit was calculated to compare side-to-side performance. Maximal kicking velocity improved progressively from the U-9 to U-16 age groups for the preferred leg and from U-16 to U-18 for the non-preferred leg, and continued to improve moderately but non-statistically significant until U-23. The stage of greatest kicking velocity development was between 13 and 16 years of age. There is a kicking deficit with the non-preferred leg and its values remain steady (9.43%-18.18%) without significant changes in players from U-9 to U-23 categories.

**PALABRAS CLAVE:** football; kicking; performance; ability; testing; non-preferred leg

**RESUMEN**

El objetivo de este estudio fue examinar la evolución del rendimiento máximo de golpeo de balón a lo largo de la edad en futbolistas jóvenes de élite. Un total de 175 fueron divididos en 11 grupos edad (U-9 hasta U-19), además del equipo filial del club (U-23). Se registró la velocidad máxima de golpeo con la pierna dominante y no dominante mediante radar. El déficit de golpeo fue calculado para comparar el rendimiento entre ambas piernas. La velocidad máxima de golpeo aumenta progresivamente de forma significativa desde U-9 hasta U-16 con la pierna dominante y hasta U-18 con la no dominante, y sigue aumentando de forma no significativa hasta U-23. La etapa con mayor incremento de la velocidad de golpeo fue entre U-13 y U-16. Existe un déficit de golpeo con la pierna no dominante y sus valores permanecen estables (9.43%-18.18%) sin cambios significativos desde U-9 hasta U-23.

**PALABRAS CLAVE:** fútbol, velocidad, habilidad, rendimiento, golpeo, test, lateralidad, edad

## INTRODUCTION

Kicking ability represents the most frequently used and determinant soccer-specific skill (Barfield, Kirkendall, & Yu, 2002; Gonzalez-Jurado, Pérez, & Floría, 2012; Katis, Kellis, & Lees, 2015) since, besides being used in passes, crosses, and clearances, it is also used to score goals and win games.

The performance of soccer kicking depends on the kicked ball velocity and accuracy (Lees and Nolan 1998). Although the kicking accuracy can be an important factor to success, the kicking performance in soccer has been evaluated predominantly by maximum ball velocity (Katis et al. 2013; Malina et al. 2015). Assuming that the kick is accurate, the chance of scoring increases with an increased ball velocity as there is less time for the goalkeeper to react (Dörge et al. 1999). Moreover, achieving maximal kicking performance with both legs leads to an advantage for the soccer player because it provides attacking players with more situations to shoot.

However, there is an agreement across studies that, ball velocity is significantly higher after a kick with the preferred leg in comparison to the non-preferred one (Bloomfield et al. 1979; McLean and Tumilty 1993; Nunome et al. 2006). There is a Kicking deficit (KD) with the non-preferred leg that could be defined as the percentage of the difference between the maximal velocity obtained for each player with the non-preferred leg in relation to the preferred leg (Rodríguez-Lorenzo, Fernández-del-Olmo, Sanchez-Molina, & Martín-Acero, 2016).

Due to this inherent importance, the study of maximal kicking velocity in soccer, has raised scientific interest (Masuda, Kikuhara, Demura, Katsuta, &

Yamanaka, 2005; Young & Rath 2011; Salinero et al., 2013), resulting in several studies that explore the effects of different strength training in maximal kicking velocity (Rodríguez-Lorenzo et al. 2016). These studies showed that explosive strength training programs, in combination with regular soccer training, can increase ball velocity values in soccer players (Sáez de Villarreal, Suarez-Arrones, Requena, Haff, & Ferrete, 2015; Ramírez-Campillo et al. 2014, 2015). For all these reasons, improving maximal kicking velocity with each leg, is becoming an important goal for strength and conditioning coaches.

The effect of age on kicking performance has not been extensively studied (Rodríguez-Lorenzo, Fernández-del-Olmo, & Martín-Acero, 2015). Age has been reported to positively affect maximum kicking velocity (Bacvarevic et al. 2012; Luhtanen, 1988; Marques et al. 2016), but the age range examined in these studies was limited. Indeed, there is no information in the scientific literature regarding the annual kicking performance development in a wide range of age, and this lack of data is even higher in the non-preferred leg.

Accordingly, the purpose of this study was to examine the evolution of kicking performance with both legs and KD with age, in young elite soccer players, to gather information that may be used for specific training prescription.

## Methods

*Participants*

A total of 175 male soccer players (aged 8.74–26.39 years) belonging to the Real Club Deportivo de la Coruña youth development programme (from U-9 to U-18), were tested as a part of their athletic training program during the final month of the 2012-2013 competitive season. These players were selected by the club among the best in the Northwest of the Iberian Peninsula, passing numerous filters, both to enter the club and to progress within it over the years. Therefore, we can consider them as elite players in their respective categories. The players were divided, exactly the way they are matched in training and competition and according to the football federation rules, in eleven age categories from U-9 to U-19, in addition to the club's second team (U-23: between 19 and 23 years old) (Table 1). Written informed consent was obtained from the players and their parents. 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.

*Desing*

The experiment was conducted within a single testing session, at an ambient temperature of 16 to 18°C. Four familiarization sessions were conducted where subjects practiced maximal kicking tests, in order to minimize any learning or habituation effects. To avoid inter-observer variability, the same experienced investigator tested all subjects.

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.

A modified version of the kick test described by Markovic et al. (2016) was used to measure maximal ball velocity. Foot preference was self-selected based on the players response to which foot they preferred to kick with for maximal ball velocity. The participants were instructed to perform an instep kick of a stationary ball of standard size and standard inflation (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.

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 $m \cdot s^{-1}$ and 67.04 $m \cdot s^{-1}$ with accuracy of ±0.045 $m \cdot s^{-1}$. 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.

*Data analysis*

The trial with the highest ball velocity was selected as the kicking performance measure for the preferred and for the non-preferred leg. Kicking deficit (KD) variable was calculated according to the following formula Rodríguez-Lorenzo, Fernández-del-Olmo, Sanchez-Molina, & Martín-Acero (2016):

$$KD = \left(\frac{KVdomMax - KVnodomMax}{KVdomMax}\right) \cdot 100$$

where *KVdomMax* and *KVnodommax* are the maximal velocities achieved with the preferred and non-preferred leg, respectively.

Normal distribution of the variables was confirmed using the Shapiro-Wilk W-test, whereas the homogeneity of the variance was verified using the Levene test. We conducted an ANOVA of repeated measurements with one intrasubject factor (leg) and one intersubject factor (age-group) over maximal kicking

velocity. In case of significant interactions, we conducted post-hoc analysis post-hoc analysis with Bonferroni corrections for the tracing of differences among age groups and between legs respectively. Effect size was evaluated with η2 (partial eta-squared). One-way analysis of variance (ANOVA) was used to evaluate age group differences in Kicking Deficit. The Tukey post-hoc test was used to specify where significant differences lay. All statistical analyses were performed using SPSS version 21 (SPSS, Chicago, IL). Statistical significance was set at $p < 0.05$.

**Table 1.** *Mean and standard deviations of kicking performance and kicking deficit. Significant differences between age groups.*

| Group | Age | Kicking Performance (km/h) | | KD (%) |
|---|---|---|---|---|
| | | Preferred leg | Non-preffered | |
| U-9 (n=12) | 9.13 ± 0.23 | 69.92 ± 4.15 [a] | 57.74 ± 4.54 [b] | 17,26 ± 6,68 [#] |
| U-10 (n=12) | 10.14 ± 0.26 | 71.72 ± 4.13 [b] | 63.62 ± 4.34 [c] | 11,14 ± 6,23 [#] |
| U-11 (n=15) | 11.08 ± 0.21 | 74.29 ± 4.56 [b] | 64.30 ± 7.34 [c] | 13,36 ± 9,48 [#] |
| U-12 (n=15) | 12.00 ± 0.28 | 79.02 ± 3.98 [d] | 64.56 ± 2.77 [c] | 18,18 ± 3,73 [#] |
| U-13 (n=15) | 13.05 ± 0.22 | 82.49 ± 4.47 [e] | 70.23 ± 1.81 [d] | 14,79 ± 7,44 [#] |
| U-14 (n=19) | 14.04 ± 0.32 | 92.65 ± 7.06 [f] | 80.15 ± 8.45 [g] | 13,27 ± 9,18 [#] |
| U-15 (n=16) | 15.12 ± 0.25 | 100.42 ± 7.10 [f] | 82.44 ± 10.29 [h] | 18,08 ± 6,52 [#] |
| U-16 (n=15) | 16.21 ± 0.13 | 108.33 ± 6.53 [i] | 90.77 ± 6.33 [j] | 16,18 ± 3,64 [#] |
| U-17 (n=13) | 17.11 ± 0.26 | 106.43 ± 5.65 [i] | 90.66 ± 9.07 [j] | 14,71 ± 5,42 [#] |
| U-18 (n=12) | 17.91 ± 0.23 | 107.32 ± 7.99 [i] | 95.30 ± 8.29 [i] | 11,02 ± 6,91 [#] |
| U-19 (n=11) | 18.98 ± 0.30 | 107.98 ±5.70 [i] | 97.57 ± 2.66 [i] | 9,43 ± 4,97 [#] |
| U-23 (n=20) | 22.11 ± 1.89 | 114.74 ± 6.12 [i] | 100.43 ± 5.11[k] | 12,40 ± 3,25 [#] |
| *Note.* KD = Kicking Deficit. | | | | |
| Significantly different ($p < 0.01$) from: [a] U-12 to U-23; [b] U-13 to U-23; [c] U-14 to U-23; [d] U-9 and U-14 to U-23; [e] U-9 to U-11 and U-14 to U-23; [f] any other group; [g] U-9 to U-13 and U-16 to U-23; [h] U-9 to U-13 and U-18 to U-23; [i] U-9 to U-15; [j] U-9 to U-14 and U-19 to U-23; [k] U-9 to U-17; | | | | |
| [#] Nonsignificant. | | | | |

## RESULTS

The mean (+ SD) data for maximal kicking performance with both legs, and KD are presented in Table 1. The Anova of repeated measurements showed a main effect of Leg (F = 579.495, P = .000, η2 = 0.82) and Age-group (F = 81.56, P = .001, η2 = 0.85) over maximal kicking velocity. There was a significant Leg*Age-group interaction (F = 3.55, P = .000, η2 = 0.21). As can be seen in Table 1, post-hoc analysis revealed significant differences between age groups

in maximal kicking performance. However, there were no significant differences in maximal kicking velocity with the preferred leg among U-16, U-17, U-18, U-19 and U-23 groups. There were no significant differences in maximal kicking velocity with the non- preferred leg among U-18, U-19 and U-23 groups. Finally, there were no significant differences in KD among age groups.

Regarding the kicking performance between legs, maximal kicking velocity was significantly higher with the preferred leg in all age-groups (Figure 1).

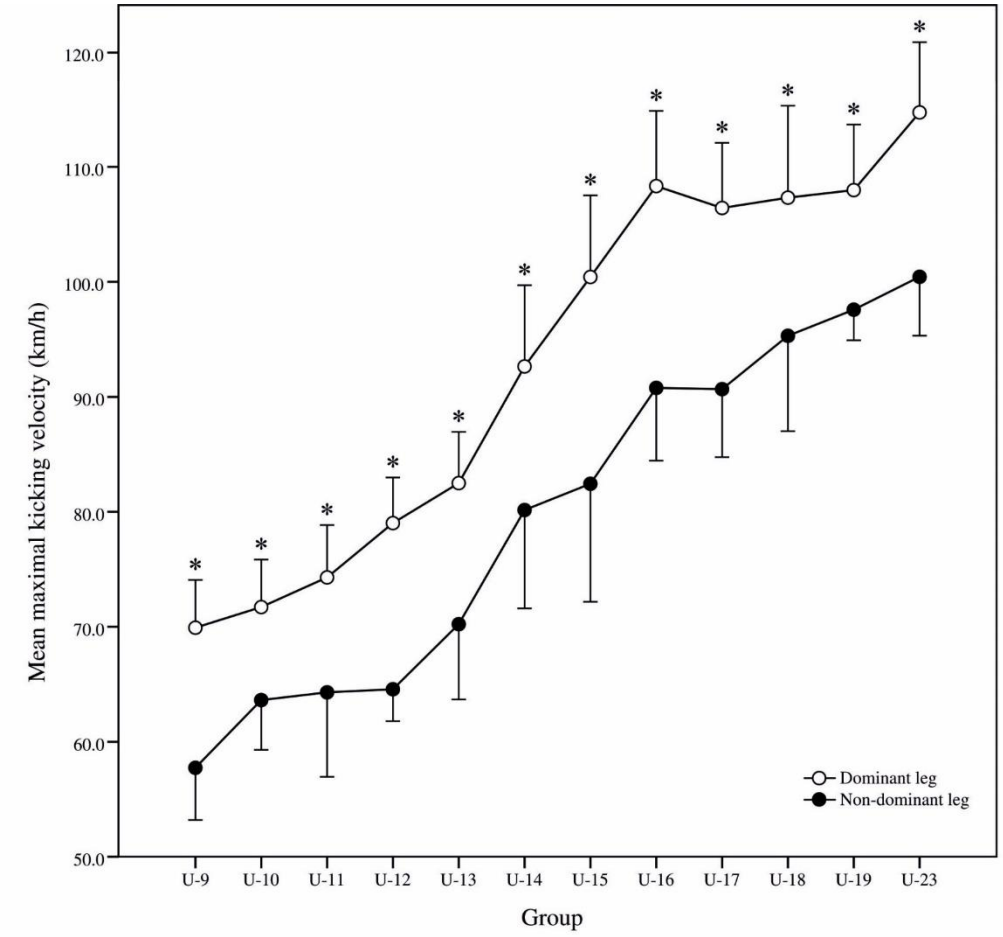


**Figure 1.** Maximal kicking velocity with the preferred and non-preferred leg for different age groups.

## DISCUSION

As far as we are aware, this is the first study to thoroughly investigate the evolution of kicking performance and Kicking Deficit (KD), in a wide range of age, in elite soccer players. Our main finding was that maximally kicking velocity with the preferred leg improved progressively from the U-9 to U-16 age groups, whereas moderate. However, with the non-preferred leg maximal kicking velocity continued to improve until U-18 group. In addition, another important finding was that this is the first study that reveals the stability of KD among ages in elite soccer players.

Kicking, like many of the skills in football, has been shown to develop from an early age. Bloomfield, Elliott & Davies (1979) points out that kicking ability develops rapidly between the ages of 4 and 6 years and at the mean age of 11.2 years a mature kicking pattern is achieved by 80% of the children. Nonetheless, ball velocity increments associated with age are likely not only due to skill development of the kicking pattern, but also due to the increased body size and muscle strength associated with growth and maturation (19). This is supported by the observation that the greatest improvements in kicking performance, in our study, occurred from U-13 to U-16 age groups, where the most marked changes associated with growth and maturation occurred (Malina et al. 2005). Our findings are consistent with Luhtanen (1988), who also reported a positive effect of age on kicking performance with the preferred leg between U-10 and U-17 years old, and with Bacvarevic et al. (2012), who also reported a positive effect of age on kicking performance with both legs between U-12 and U-15 years old. The recent study of Marques et al. (2012) demonstrated that maximum kicking velocity with the preferred leg increased across U14, U16 age categories in youth elite soccer players, but no significant differences were found among U16 to U18 age groups. Our results confirm that no significant effect of age was found between U16 to U18. However, one unanticipated finding was that kicking velocity of U-16 players, did not differ from that of U-23 players, indicating that at the mean age of 16.21 years a mature kicking performance is achieved. Nevertheless, with the non-preferred leg a mature kicking performance is not achieved up to the mean age of 17.91 years.

Regarding the results that compare maximum kicking performance between legs, we found that ball velocity is significantly faster after a kick with the preferred leg compared to the non-preferred one in all age groups, and confirmed that KD is a constant element in elite soccer players. These results are consistent with those of a great deal of the previous work in this field with different kinds of sample (Nunome et al., 2011; Bacvarevic et al. 2012) and different techniques and kick conditions (McLean and Tumilty 1993; Bacvarevic et al. 2012; Marques et al. 2011). This is the first study that reveals the stability of Kicking Deficit (KD) among ages, with values between 9.43 % and 18.18%, without significant changes among the players from U-8 to U-23 categories.

From a practical perspective, Kicking Deficit (KD) may be a useful index to evaluate the individual capacity of each player to perform at similar levels with both legs. Therefore, the outcomes from the current study may constitute a rough guideline for strength and conditioning coaches to monitor and to assess the current status and progress of their players.

Our work has presented some limitations. These results can only be applied to male populations of similar characteristics. The use of these reference values in women’s soccer is not appropriate since it has been reported that maximal kicking velocity in females is significantly lower than males (Barfield et al. 2002; Shan 2009).

## CONCLUSIONS

In summary, this study describes the cross-sectional evolution of kicking ability with both legs in elite male youth soccer players. Our results show that KD stays steady without significant changes among the ages. Moreover, the maximal kicking velocity improves with age, markedly from U-11 to U-15, and much more slowly thereafter. Further longitudinal studies and across the sexes are required for a better understanding of the effect of age on maximal kicking velocity.

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