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Original Article

A comparison of ball velocity in different kicking positions with dominant and non-dominant leg in junior soccer players.

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Abstract
Problem Statement: The aim of this study was to compare the ball velocity in different kicking conditions with dominant and non-dominant leg in junior soccer players.
Approach: Sixteen junior soccer players (age 17.6±0.6yr, height 1.76±0.06m, and weight 67.9±5.2kg) participated in this study. All participants kicked a soccer ball three times in seven conditions with the dominant and non-dominant leg. 1) Kicking the ball from 11m straight forwards, 2 and 3) kicking the ball from 11m to the left and right side of the goal, 4 and 5) kicking the ball straight forwards from 11m after a pass from the left and right side, 6 and 7) kicking the ball straight forwards from 11m after a pass that came from a diagonal position (45º) from the left and right side. The highest ball velocity was used for analysis.
Results: Significant differences were found in ball velocity between the dominant and non-dominant leg in all conditions ($p<0.001$). For the dominant leg also significant differences were found in the kicking of eleven meters (ideal conditions) compared with: the perpendicular passing kick after the ball on the right ($p=0.0024$) and left ($p=0.0080$) and also with a diagonal kick after pass (45 °) of the ball on the right ($p=0.0017$) and left ($p = 0.0381$). Significant differences in the kicking with the non-dominant leg were found when kicking from eleven meters to the right side of the goal in comparison to: the kick under the same conditions, to the left side of the goal ($p=0.0243$) after pass and shot from the left side perpendicular ($p=0.0222$).
Conclusions/Recommendations: kicking velocity is influenced very much under different conditions when kicking with the dominant leg while for the non-dominant leg this influence was small, because the non-dominant leg is less trained, so the values of velocity in different conditions, in addition to being the lowest, are closer than those obtained with the dominant leg.
Keywords: ball velocity, kinematic parameters, asymmetry, lower limbs.

Introduction

Soccer is considered as the most popular sport worldwide and is practiced by about 200 million players [1], including professionals and amateurs. It is described as a sport that requires a lot of energy and is physically fatiguing due to accelerations, decelerations, jumping, tackling and shooting. The main objective of this sport is to score the most goals, which gives victory. This is usually achieved through multiple attempts of kicking on the goal [2]. According to the literature, the greatest scoring opportunities arise in situations of high velocity [3], with little exchange of passes or when there are only a few touches on the ball in a swift action. Since these kind of tasks takes time for the defence to position them self properly [4, 5].

Ismail et al. [2010] stated that the dominant variables contribute to the force rate are the velocity and the distance when making the instep kick [6].

Given its importance, the act of shooting has received much attention from scientists, who have analysed different forms of execution in various populations. It is important to understand that there are numerous factors that can influence shooting, like the ball velocity, accuracy and effectiveness [7, 8].

The extent to which this act is accomplished needs careful consideration. For example, shooting with or without prior displacement and kicks with dominant and non-dominant limb ratio are some of those factors. Each of these factors can significantly influence this technical movement and, consequently, the end result of that action [4]. However, most studies focused exclusively on the analysis of kicks made with the dominant limb. Finally, thinking on the several players who kick with their non-dominant leg during the games and with the same facility, we intend to investigate this interesting feature, examining if there's this tendency in young

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players. Therefore, the aim of this study was to examine the effect of different constraints on the ball velocity when kicking was done with the dominant and non-dominant leg. Thus, we intend to answer two key questions: Firstly, what are the differences in the ball velocity when kicks are performed under different conditions ranging from kicking a ball on a spot to kicking balls that were preceded by a pass. Secondly, we aim to investigate to what degree of kicking with the dominant leg or non-dominant limb influences the ball velocity under these different conditions. It was hypothesised that the kicking velocity was decreased from kicking a ball from ideal conditions to kicking it after a pass from the left or right side. These differences would occur in both kicking with dominant and non-dominant leg since the ball isn't in motion, so the perception of the contact point and the contact of the foot with the ball is easier.

Methods

Subjects

Sixteen male junior soccer players (age 17.6 ± 0.6 yr, body mass 67.9 ± 5.2 kg, height 1.76 ± 0.06 m, training experience 8.1 ± 2.6 yr) participated in this study. All were experienced soccer players with their right leg as their dominant leg, playing in the second division for juniors in the national competition of the country. The participants were fully informed about the protocol before participating in this study. Informed consent was obtained prior to all testing from all participants, in accordance with the recommendations of local ethical committee and current ethical standards in sports and exercise research.

Procedures

Prior to the execution of different tests all players performed their usual warming of around 15 minutes, which included jogging and kicking drills. All participants were previously familiarised with the procedures of each test in an own session before the test session. After the warming up the participants were instructed to kick a regular ball (Adidas ball Roadmap™, circumference 69cm and weight 430gr) as hard as possible under seven different conditions with the dominant and non-dominant leg.

1) Kicking the ball from 11m straight forwards,
2 and 3) kicking the ball from 11m to the left and right side of the goal
4 and 5) kicking the ball straight forwards from 11m after a pass from the left and right side
6 and 7) kicking the ball straight forwards from 11m after a pass that came from a diagonal position (45º) from the left and right side.

In condition 1 the participants had to kick the ball that lied still on the penalty spot (11 meters from the goal) at the goal without any constraint on the direction of the kick in the goal. This was also called the ideal situation. The participants were allowed a running approach of 5m. An attempt was successfully when it hit the goal. Once three successful attempts were captured they performed the same procedure with the non-dominant leg. The participants were not informed about the total number of kicks that they had to perform in each condition. This was done to preserve them for only aiming for the target and not trying to kick as fast as possible. The participants had approximately 1 min rest between each attempt to avoid an effect of fatigue on kicking velocity.

In condition 2 and 3 the participants had to kick the ball from 11m similar as in condition 1. However the goal was now divided into two equal parts, by a tissue of 1.5 m in width (Figure 1). The participants firstly had to kick the ball to the right side (condition 2) until three successfully attempts were recorded followed with kicks of the non-dominant leg. After these kick the participants had to kick to the left side of the goal with both legs (condition 3). In cases where the ball touched the fabric, the kick was invalidated.

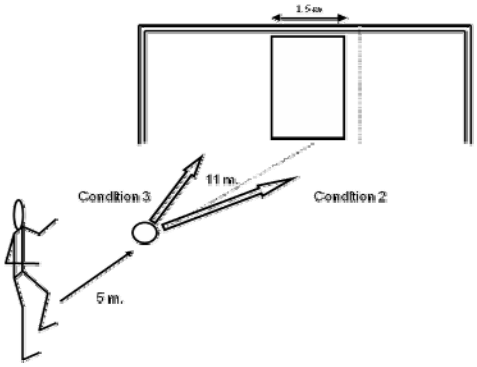


Figure 1. Set up for kicking in condition 2: kicking a ball from 11m to the right side and condition 3: kicking a ball from 11m to the left side.

In condition 4 and 5 the participants had to kick the ball after a pass made by one of the researchers from a distance of 10 meters with velocity from a position perpendicular to the trajectory of the kick. In

condition 4 the pass was performed on the right side. In condition 5 the pass came from the opposite side (Figure 2). The attempts were valid when the kick was performed in an area corresponding to a circumference of 1.5 m in diameter and whose centre was the penalty mark. Again, the athletes allowed to approach the incoming ball from 5m distance.

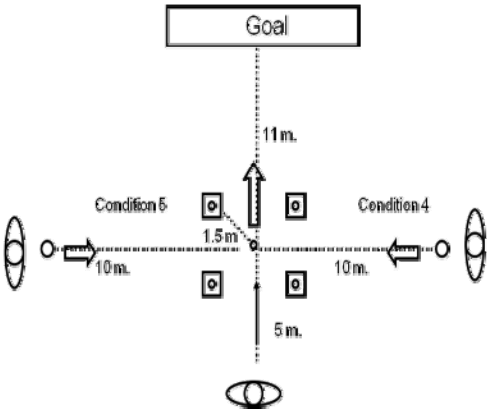


Figure 2. Set up for kicking in condition 4: kicking a ball from around 11m after a pass perpendicular from the right side and condition 5: kicking a ball from around 11m after a pass perpendicular from the left side.

As in the previous two conditions in conditions 6 and 7 the pass was made by one of the researchers at a distance of 10 meters, with velocity. However the pass was now given from a diagonal position (45 degrees angle) to the trajectory of the kick (Figure 3). In condition 6 the ball came from the right side and in condition 7 the ball came from the left side. For the rest the same procedures (run up and validity) as in the other conditions were used.

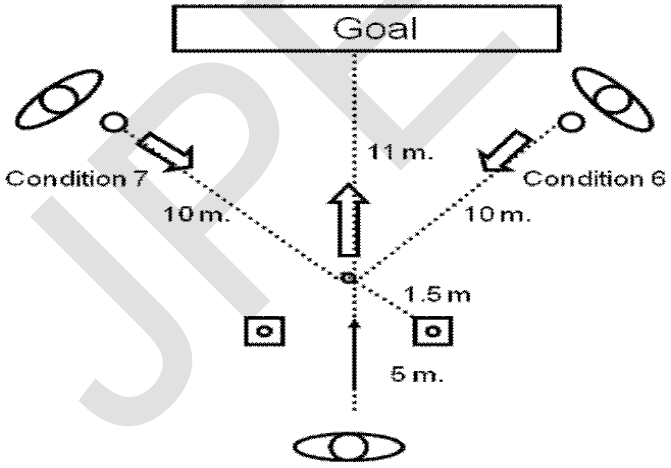


Figure 3. Set up for kicking in condition 6: kicking a ball from around 11m after a pass 45 degrees from the right side and condition 7: kicking a ball from around 11m after a pass 45 degrees from the left side.

Measurements

To determine the velocity of the ball shooting a radar gun (3300 Sports Radar, Sports Electronics Inc.) with an accuracy of 0.03 ms-1 handled by the same user was used. The average of the three kicks in every condition was taken for further analysis. The type of terrain was made up of synthetic grass, which avoids the problem of bumps. In order to correctly determine the velocity of the ball kick, the radar gun was placed in the same place (behind the goal) and facing the path of the ball. The order for testing corresponded to the sequence of presentation of the procedures.

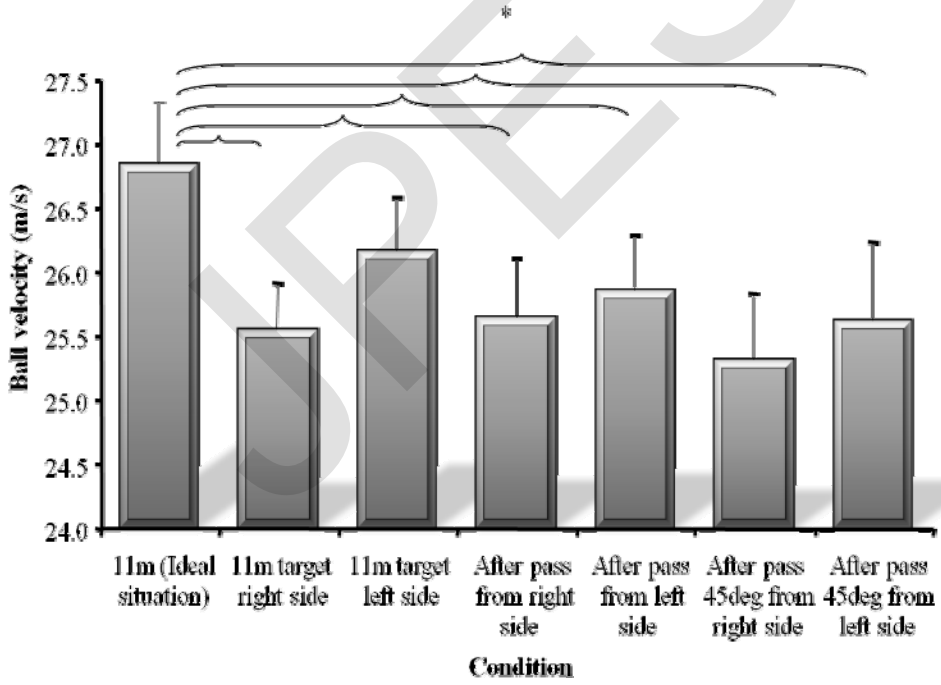
Statistical Analysis

To compare the effects of kicks with the dominant and non-dominant leg and conditions a 2 (kicking leg: dominant vs. non-dominant) x 7 (different conditions) Analysis Of Variance (ANOVA) for repeated measures was used. A *post hoc* test was used to locate significant differences. Coefficients were calculated for Intra-Class Correlation (ICC) and variation (CV) for the study of reliability. The level of significance was $p \leq 0.05$.

To evaluate the differences in kicking velocity between the dominant and non-dominant leg under the different conditions first the difference in kicking velocity between the dominant and non-dominant leg was calculated. Then these differences were compared by a one-way ANOVA for repeated measures between to identify if there was a different effect of the condition upon these kicking velocities between both legs.

Results

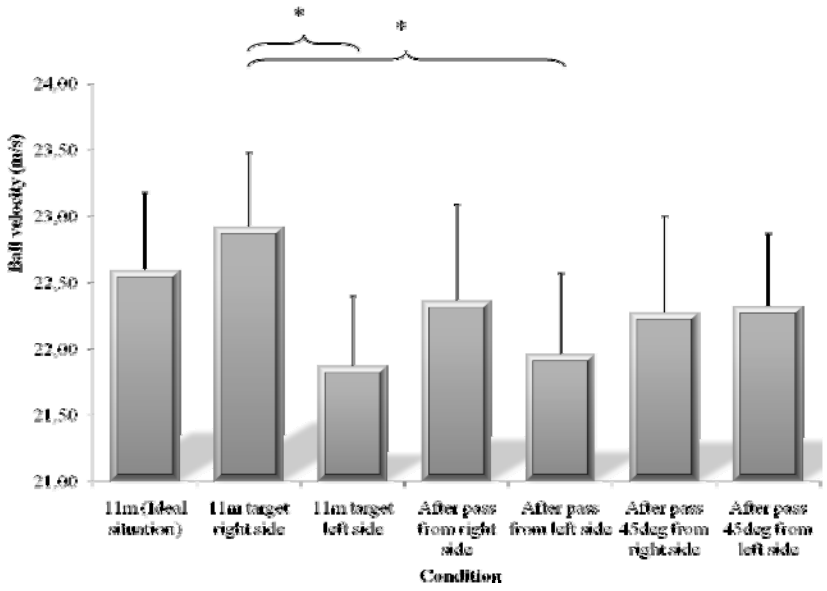
For most tests, the perceived reliability data were quite high, with ICC 0.93 and CV average and 5.4% respectively. The One-way ANOVA with repeated measured revealed a significant effect of kicking with the dominant compared to kicking velocity with the non-dominant leg ($p<0.0001$) i.e. the kicking performance with the dominant leg was higher in all conditions compared to the kicking velocity with the non-dominant leg. However, the different conditions had a different effect upon the kicking velocity when kicking with the dominant leg or the non-dominant effects. When kicking with the dominant leg a significant effect of the different conditions was found ($p=0.038$) while no significant effect was found when kicking with the non-dominant leg ($p=0.36$). Post hoc comparison showed that for kicking with the dominant leg the ball velocity under from 11m without other constraints was significantly higher than under all under conditions ($p<0.041$) except with the condition where the participants had to kick to the left side of the goal ($p=0.235$; figure 4).



* Indicates significant differences in ball velocity between these two conditions ($p \leq .05$)

Figure 4. Ball velocity when kicking in different conditions with the dominant leg.

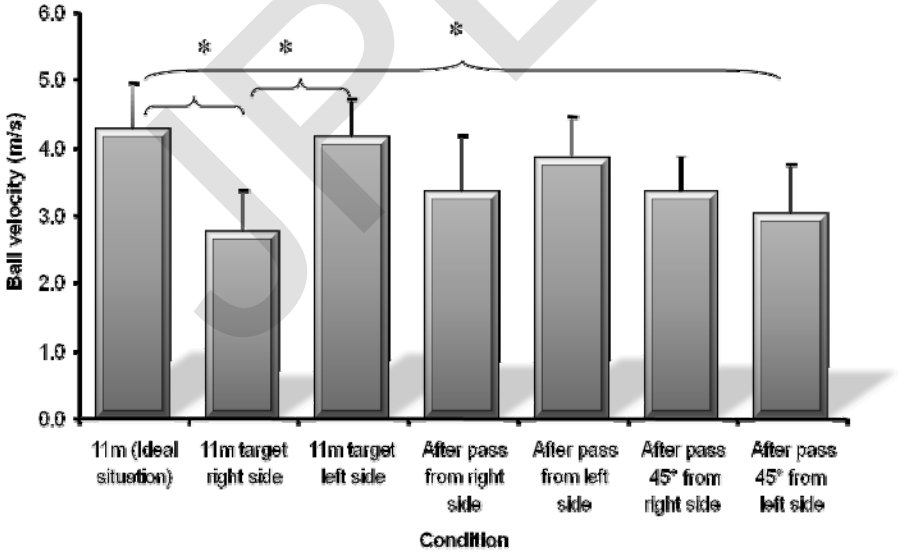
For kicking with the non-dominant leg (figure 5) only a significant higher ball velocity was found between kicking to right side from 11m when compared to kicking to the left side of the goal ($p=0.024$), or after the perpendicular pass to the left ($p=0.022$; figure 5).



* Indicates significant differences in ball velocity between these two conditions ($p \leq .05$)

Figure 5. Ball velocity when kicking in different conditions with the non-dominant leg.

When comparing the difference in kicking velocity between kicking with the dominant and non-dominant leg in the different conditions no significant differences were found (p=0.113). However, again post hoc comparisons showed significant differences between kicking to the right side with kicking under ideal situations (p=0.035) and kicking to the left side (p=0.026; figure 6) and between kicking under ideal situations with kicking after a pass 45 degrees from the left side (p=0.038; figure 6).



* indicates a significant difference in ball velocity between these two conditions.

Figure 6. Difference in ball velocity between kicking with the dominant leg and non-dominant leg in different conditions.

Discussion

The aim of this study was to examine the effect of different conditions on the kicking velocity for both the dominant and the non-dominant leg. The main finding was that significant effects of the different conditions were found when kicking with the dominant leg, while no significant difference was found when kicking with the non-dominant leg.

In soccer, several studies have examined the velocity of the ball during kicking in professional players [9, 10], amateurs [11, 12],in steps of formation [13] and college students [14]. Unfortunately, on this issue most studies examined the kicking velocity at eleven meters from the goal (the penalty mark) in static conditions, without prior velocity of the ball. Furthermore, without controlling the velocity of the ball when the kick runs under different conditions, for example, whether because of putting the ball on one side of the goal, either by holding the kick after passing perpendicular or diagonal to the trajectory of the ball (i.e. prior velocity of the ball). In addition, there are few studies that compare the velocity of the ball during the kick with the dominant and non-dominant conditions mentioned above. This gives the present study a greater originality, as a close approach to the game context.

Based on literature review, we realized that the ball velocity during shooting in ideal conditions varies between 20 and 35 ms-1, falls within the range where the rate observed in this study, 26.8 ms-1, corresponding to a range of variation from 24.4 to 30.1 ms-1, for the dominant leg in a position regarded as optimal [11, 12]. However, it is noted that the variation in age and time of practice for athletes, as well as the methodology applied could cause the different results [15]. In the lower age, strength and coordination of the lower limbs, as well as technical ability, are still in development, which justifies a lower performance in the velocity of the ball [16]. However, Barbieri [17] showed that the values for the velocity of the same kick with the dominant leg was 24.2 ± 2.2 ms-1 and the non-dominant leg of 21.6 ± 2.3 ms-1, with a statistically significant difference, which, according to the author, stems from the influence of kinematic parameters, such as the linear velocity and angular acceleration, among others. We would expect lower values because the athletes were between 13 to 14 years, although in this case it would be expected that the results were considerably lower. It is probably not the case because these are elite athletes whose sport is exercised, on average, for 7.6 ± 1.2 years (very close to what was found in this study) [17].

The present study found significant differences in kicking in ideal conditions over the same gesture after passing the ball perpendicularly to the right and left. This result was possibly derived from the type of instruction given to participants (e.g. to shoot at full velocity and hit the target, after passing both perpendicular to the right and the left), which may have influenced the mindset of the motor and consequently the movement of the performers with dominant leg, promoting a decrease in running velocity of approach just before ball contact, thus affecting the velocity of the ball. We can assign these values to the fact that in recent cases the ball was in motion (i.e. with a prior velocity), being more difficult for the performer, compared to what happens under ideal conditions to determine the point of contact with the ball.

Regarding the non-dominant limb, the analysis of several studies [18, 19, 20, 21] indicated that the ball velocity of the kick with this member varies considerably between 18.3 and 27.1 ms-1, under ideal conditions. In this study, the ball velocity was 22.6 ms-1. On this subject, Mognoni et al. [1994] examined this variable in players with a mean age of 17.4 years, who played in the national championship and they could see velocities of 21 ms-1, very similar to ours [20]. Moreover, Nunome et al. [2006], perceived velocity values of 27.1 ms-1 in elite athletes (~ 17 years). These values were unexpected, since these players trained this motor skill. Finally, a study of amateur players (~ 21 years) made by Barfield [1995], indicated that the velocity of the ball during the kick was 24.3 ms-1 i.e. aged athletes had higher values of ball velocity, as would be predicted. Also in relation to the non-dominant lower limb, statistically significant differences in the velocity of the ball when the kick was done for the right side, compared with either the kick to the left side of the goal or after passing perpendicularly to the left were found. This result is certainly the lowest velocity of the ball on the left. Under this assumption, the minimum velocity can be explained by greater difficulty in performing the movement and transfer velocity of foot to ball. As such, no assessment of other variables that may be implied in this event makes this study unable to deepen the reasons for these differences. In fact, the lack of studies that assess the velocity of the ball kick under these conditions will not allow us to compare the results
and thereby draw more sustained and complete conclusions. Finally, differences in velocity of the ball between the dominant leg and non-dominant were significantly. However, again it was only possible to compare the values inherent in the kick run in ideal conditions with other studies.

McLean and Tumilty [1993] reported, in junior players, velocity values with the dominant and non-dominant of 21.9 and 18.3 ms-1 ms-1, respectively. Although the velocity values were lower, the velocity of the ball during the kick, for each of the lower limbs was also significant ($p<0.05$). These authors attributed this result to differences in movement kinematics. Other studies [22-23] focused their analysis to adult athletes (aged between 20 and 27 years of age) also obtained in all cases, significant differences in velocity the ball when shooting with the dominant and non-dominant leg. The authors considered that the linear velocity of limb that promotes the impact with the ball and the angular velocity of knee and leg in kicks with the dominant limb are greater than those of non-dominant leg. They considered that these kinematic parameters are responsible, in part, by differences between the two legs.

In a more recent study, Barbieri [2007] updated and concerned with the analysis of the differences in ball velocity of the kick, both in ideal conditions as prior to displacement of the ball. Thus, in the case preceded the kick of passing, the values obtained were 23.9 ± 2.7 ms-1 for the dominant leg and 21.4 ± 2.25 ms-1 for the

non-dominant leg. It should be noted that although both values were lower than ours, the difference between the average velocity of the ball between the two limbs is lower, which may be due to the fact that these young people practice more soccer today. So, there is greater concern in practice with both limbs and therefore encouraging ambidexterity. Finally, in this situation, it was found that the velocity of the ball after shooting with the dominant leg was still considerably higher than the non-dominant lower limb, as found in this study. The study of Barbieri [2007] was the only study that met with some similarity to ours, although it has been made in indoor soccer. Thus, given the scarcity of studies in this field, soccer needs more and better research on this topic.

Conclusions and Practical Applications

The ball velocity was significantly higher when the kick was performed in an ideal condition (on the spot from 11m), compared with the kick preceded by a pass when kicking with the dominant leg. However, with the non-dominant leg, no significant effect was found for the different conditions.

In summary, the results alert us to the need of reducing the difference between the contra lateral limbs, as if the non-dominant leg is properly stimulated. This may perform identical to the dominant leg. Gaining a similar income between the two legs can be achieved through the implementation of specific training sessions, which promote the improvement of technical gestures implicit in the kick and, consequently, improve the completion of the plays, reaching the main goal of a game soccer - the goal. Thus, at youth level, it is essential to focus on developing equally in both limbs. High-level players will have the ability to skilfully use the non-dominant leg, becoming more, tactical, technical and physically evolved.

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