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Original article

The influence of different exercise intensities on kicking accuracy and velocity in soccer players

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Abstract

Purpose: The aim of this study was to investigate the influence of different exercise intensities induced by a soccer specific protocol on kicking performance in soccer players.
Methods: Twelve semi-professional male soccer players participated in this study and performed maximal instep kicks before and after the implementation of an exercise protocol to determine the influence of different intensities upon kicking ball velocity and the target-hitting accuracy.
Results: Analysis of variance designs with repeated measures showed that maximal ball velocity was affected only after the most intense circuit ($F(6, 66) = 2.3$; $p = 0.041$; $\eta^2 = 0.18$), while accuracy was not affected in the protocol ($F(6, 66) = 0.19$; $p = 0.98$; $\eta^2 = 0.02$). Low and moderate intensities did not affect accuracy or kicking ball velocity.
Conclusion: These findings suggest that kicking ball velocity is influenced by high-exercise intensities. Low and moderate exercise intensities do not affect the performance of the kick, and intensity does not influence accuracy. Otherwise, it is possible that other mechanisms (not only physiological) may influence players during the exercise.

Keywords: Exercise intensity; Fatigue; Kicking soccer; Pacing

1. Introduction

Exercise intensity in sports is an aspect that determines the characteristics of effort and, consequently, is also an important factor for control and regulation of training.[1,2] The type of intensity developed in each sport determines its specificity of effort. Particularly in soccer, the type of effort is intermittent due to permanent changes in intensity, including alternation between critical moments of high-intensity and moments of near rest.[2–4] In fact, in soccer, there seems to be 2 patterns of effort: the pattern as a result of short-term high-intensity effort and the pattern as a result of long-term exercise.[5,6]

In general, regarding high-intensity efforts, soccer players perform 150–200 brief, powerful actions during a game; for example, sprinting, changing pace and direction, tackling, accelerations, decelerations, and jumping.[2] This high level of intensity is considered decisive in soccer and causes high levels of fatigue, which affect the player's performance during a game.[4,5,7]

However, the importance of intensity in soccer activities is not limited to high-intensity moments. In fact, the game is also characterised by lower levels of intensity representative of the other type of actions that are also required during the game.[1,4,5] Because of this, it would be interesting to determine the influence of lower and different intensities on player performance. It is known that each level of intensity requires different levels of strength and endurance in relation to each action.[1,5] Therefore, each action can be conditioned by the state of temporary and accumulated fatigue in players; thus, these aspects have consequences on tactical and technical performance.[1,4,5,7] Because of this possible connection between exercise intensity, fatigue, and player performance, it would be interesting to better understand the influence of different intensities on soccer performance, particularly on kicking, as it is considered an important parameter for success in soccer.[4,8]

In terms of kicking performance as a result of high exercise intensity, results of previous studies showed a possible negative

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effect on motor coordination and a reduction of movement stability, especially in knee and hip range of motion, which is mainly due to fatigue.[4,9,10] Rampinini et al.[7] reinforced this idea when it was found that short passing ability decreased both during a game and after brief bouts of high-intensity activities.

However, a recent study[11] showed that this classical idea of the negative cause/effect relationship between high-intensity activities and performance skills cannot be linear, but should be variable and consider aspects such as self-unconscious effort regulation (pacing strategy), the importance of the role of perceived exertion in relation to the exercise, and the critical importance of psychological aspects: all of which were supported in recent fatigue studies.[12–19] In addition, other previous studies also concluded that soccer skills were not affected (and kicking during soccer was only minimally affected) after high-intensity exercises.[1,20] These studies advance a muscular reason, stating that knee extensor muscle strength remained unaffected in all exercise trials.[1]

Thereby, and despite the differences between the protocols used that can explain differences in the results, it seems to be expected and desirable that the investigation about the impact of different intensities on kicking performance should continue; the studies are still inconclusive, but new conclusions continue to emerge. Furthermore, most research is very focused on the effect of high-intensity efforts. In our opinion, it also seems important to understand what happens during kicking after different intensities of exercise (not only after high-intensities). Additionally, we also consider it is important to use a protocol with activities/exercises related to training and games.

Therefore, the aim of this study was to investigate the effect of different intensities induced by a soccer specific protocol upon kicking ball velocity and the target-hitting accuracy of soccer players. Although kicking performance is considered crucial for successful soccer performance, there is limited information regarding this interaction with different exercise intensities. It was hypothesised that different intensities may result in different levels of fatigue, which may affect kicking performance. Still, progressive exercise intensity may cause progressive levels of fatigue, which can result in progressive kicking performance deterioration. However, and according to recent studies, it is possible that the effect is minimal, and not linear or progressive;[1,5,11] because of this, it is also possible that, with a moderate and chosen intensity, performance can be expected to increase more so than in higher or lower intensities.

2. Methods

2.1. Participants

Twelve semi-professional male football players (age 19.7 ± 4.9 years; height 1.79 ± 0.56 m; weight 703.14 ± 77.47 N; training experience 13.0 ± 5.6 years) playing in the second division of the Norwegian National Competition in competitive period participated in this study. The subjects were fully informed about the protocol before participating in this experiment. Informed consent, in accordance with the recommendations of the Ethics Committee of the Scientific Council of PhD Course in University of Beira Interior and current ethical standards in sports and exercise research, was obtained prior to all testing from all subjects.

2.2. Design

A repeated-measures design with a group of active amateur soccer players was used to determine the influence of different intensities (fatigue) on kicking ball velocity and accuracy of soccer player subjects.

2.3. Procedures

An adaptation of the Ferraz et al.[11] protocol was used. The subjects had a familiarisation session 1 week before in which they, as a part of the warm-up, completed the circuit. This was done to avoid the learning effect. After a general warm-up of 15 min, which included jogging and kicking drills, kicking performance was tested from 11 m (penalty kick). A standard soccer ball (mass approximately 430 g with a circumference of 70 cm) was used. The instruction was to kick a regular ball with maximum force and attempt to hit a target from 11 m away; the target was a 1 m × 1 m circle that was 1 m off the ground and located in the middle of a goal (7.32 m × 2.44 m). Three attempts per condition were made.

After 3 kicks, the participants started the circuit at intensity 3 (their own preferred tempo) to obtain an idea of what their preferred tempo was. Then, all intensities were randomised (including intensity 3) to avoid a learning and/or fatigue effect. The random order was based on a random number generator. The circuit consisted of a set of specific and explosive exercises including jumping, skipping, multiple quick changes of direction, driving the ball, passing, bursts of sprinting and slow running (Fig. 1). The 5 different prescribed intensities were:

Slowest–Perform the circuit slowly and comfortably.
A bit slower–Perform the circuit at a tempo that is a bit slower than your own preferred tempo (a bit slower).
Preferred tempo–Perform the circuit at your preferred tempo.
A bit faster–Perform the circuit at a tempo that is a bit faster than your preferred tempo but not as fast as possible.
Fastest–Perform the circuit as fast as possible.

After each circuit, the participants had to kick the ball 3 times. After the 3 kicks, the participants had 5 min to rest and recover so that the previous intensity did not have an influence on the next intensity.

2.4. Measurements

The kicking ball velocity of the ball was determined using a Doppler radar gun (Sports Radar 3300; Sports Electronics Inc., Dayton, OH, USA) with ±0.028 m/s accuracy within a field of 10° from the gun. The radar gun was located 2 m behind the 11 m line at ball height during the kick. The average kicking ball velocity after each circuit was used for further analysis.

Kicking accuracy was measured with a video camera (HDR-FX100; Sony, Tokyo, Japan) placed at a distance of 12 m from the goal. The camera was positioned so that the subject did not

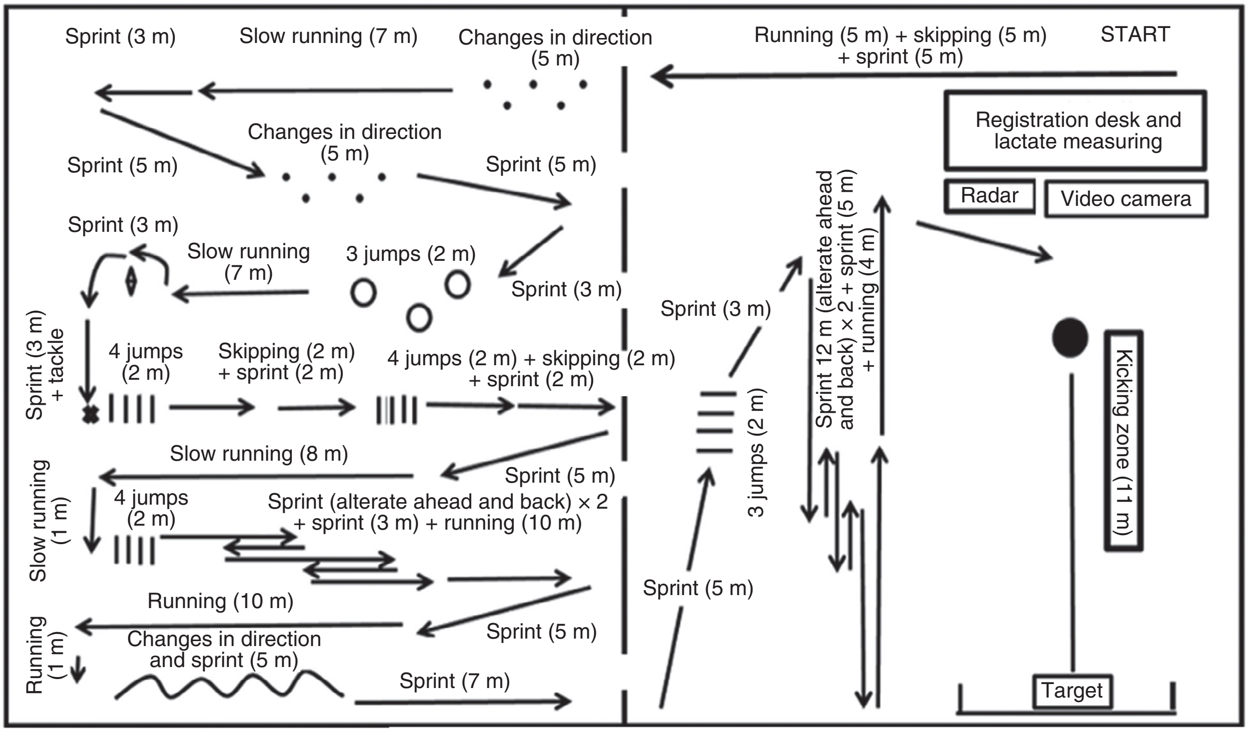

Fig. 1. Circuit design.

obstruct the field of vision between the camera and the goal. The position of the center of the ball was measured at the moment it struck the goal. Mean radial error (MRE), as described by van den Tillaar and Ettema,[21] was used as a measurement of accuracy. MRE was measured as the average of absolute distance to the centre of the target.

The time of each circuit was also measured. Participants wore a pulse belt (RS300x; Polar, Oulu, Finland) for the duration of the experiment. Heart rate (HR) was measured immediately following the completion of a circuit and just before the start of the next one, as was the rating of perceived exertion (RPE), which was on a 20-point Borg scale.[22] Lactate was measured after the warm-up and directly after the 3 kicks following each circuit. Blood was taken from the fingertip, and a lactate measurement was performed using a portable machine (Roche Accutrend Lactate Test Strips; Roche, Basel, Switzerland).

2.5. Statistical analyses

To assess differences in maximal ball velocity, a repeated analysis of variance (ANOVA) was used for kicking accuracy, HR, lactate, RPE, and time of each circuit. *Post hoc* comparisons with Holm-Bonferroni corrections were conducted to locate differences. All results are presented as mean ± SD. Where sphericity assumptions, measured by the Mauchti's tests of sphericity, were violated, Greenhouse–Geisser adjustments of the p values were reported. The level of significance was set at $p < 0.05$. Effect size was evaluated with η^2 where $0.01 < \eta^2 \leq 0.06$ constitutes a small effect, $0.06 < \eta^2 \leq 0.14$ constitutes a medium effect, and $\eta^2 > 0.14$ constitutes a large effect.[23] Statistical analysis was performed with SPSS Version 18.0 (SPSS Inc., Chicago IL, USA).

3. Results

The time to cover the circuit, average kicking ball velocity, and accuracy were not significantly different when performing the circuit directly after the warm-up compared to the later circuits ($p \geq 0.14$, Figs. 2 and 3), contrary to the lactate concentration which was significantly different ($p < 0.05$, Fig. 4) except in comparison with the slowest one. HR and RPE were significantly ($p \leq 0.02$) higher when performing the circuit at the preferred tempo for the second time (Fig. 5). The time used

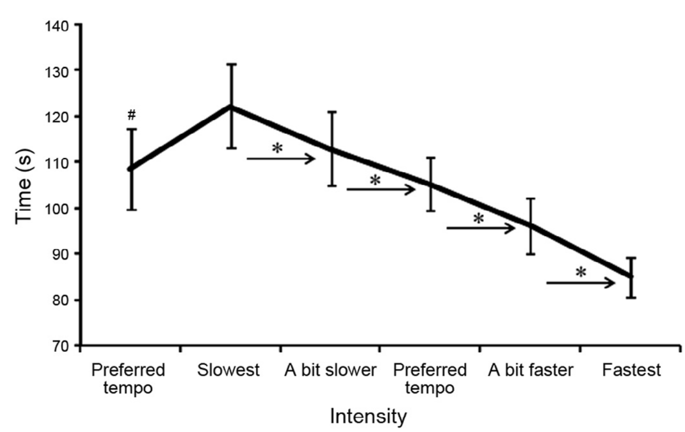

Fig. 2. Time used to cover the circuits at different intensities. *$p < 0.05$, compared with all next intensities; #$p < 0.05$, compared with all intensities except with preferred tempo and a bit slower.

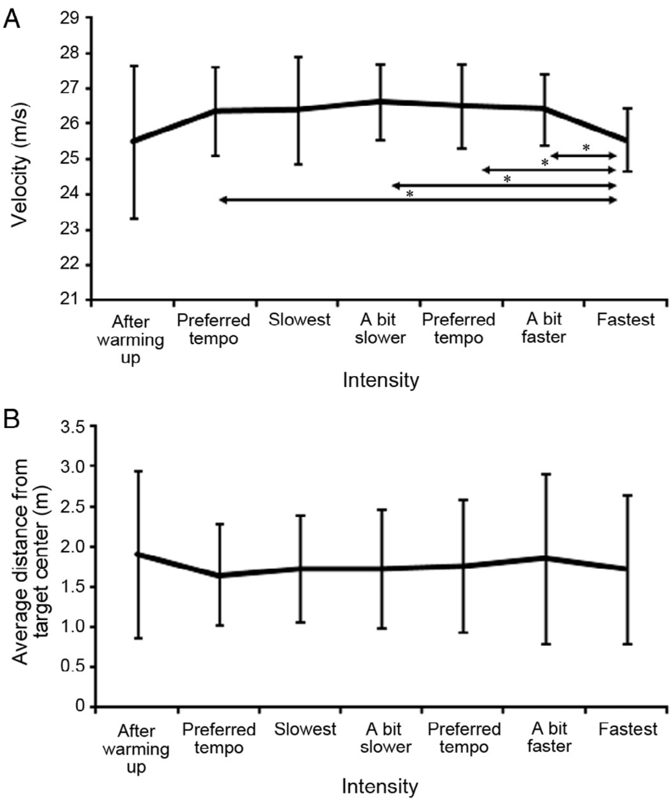

Fig. 3. Average ball velocity (A) and accuracy (B) at the different intensities averaged over all participants (mean ± SD). *Indicates a significant difference between 2 intensities ($p < 0.05$).

for completing the circuit was significantly shorter after each circuit when the intensity was increased ($F(5, 50) = 74.9$; $p < 0.001$; $\eta^2 = 0.88$; Fig. 2).

Average ($F(6, 66) = 2.3$; $p = 0.041$; $\eta^2 = 0.18$) ball velocity was significantly affected after completion of the circuit. A *post hoc* comparison showed that the ball velocity only decreased significantly at the highest intensity compared with all others, except with the one after the warm-up and the slowest performed circuit (Fig. 3A). Accuracy ($F(6, 66) = 0.19$; $p = 0.98$;

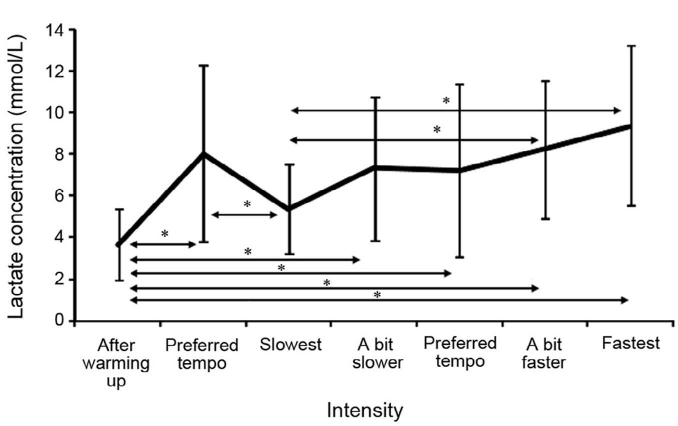

Fig. 4. Lactate concentration after each circuit at the different intensities averaged over all participants (mean ± SD). *Indicates a significant difference between 2 intensities ($p < 0.05$).

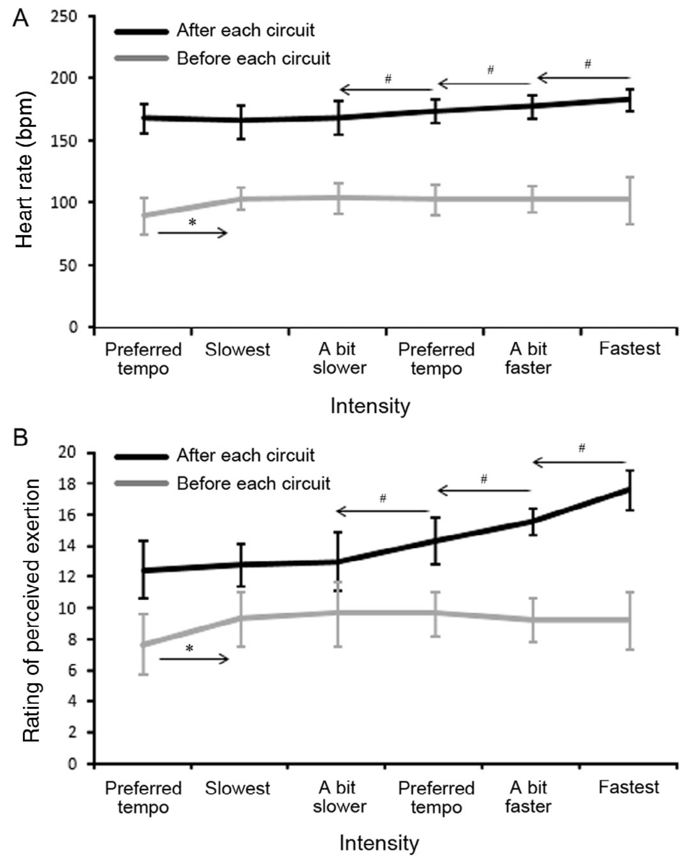

Fig. 5. Heart rate (A) and rating of perceived exertion (B) before and after each circuit at the different intensities averaged over all participants (mean ± SD). *$p < 0.05$, compared with all next intensities right of the sign; $^{\#}p < 0.05$, compared with all next intensities left of the sign.

$\eta^2 = 0.02$) did not significantly change during the protocol (Fig. 3B).

Lactate concentration changed significantly during the protocol ($F(6, 66) = 4.81$; $p < 0.001$; $\eta^2 = 0.3$). A *post hoc* comparison showed that lactate concentration was significantly lower directly after the warm-up compared with most intensities (except the slowest one). Furthermore, the lactate concentration was only significantly higher after the faster and fastest conducted circuits compared to the slowest circuit (Fig. 4).

HR and RPE before the start of each circuit changed significantly ($F(5, 40) \geq 4.07$; $p < 0.04$; $\eta^2 \geq 0.27$). A *post hoc* comparison revealed that HR and RPE only increased significantly from the preferred tempo intensity directly after the warm-up with all other intensities. When HR and RPE were measured after each circuit, they increased significantly over the exercise period ($F(5, 45) \geq 12.7$; $p < 0.001$; $\eta^2 \geq 0.59$). A *post hoc* comparison revealed that both HR and RPE significantly increased after every intensity, from the slower to the fastest circuit (Fig. 5).

4. Discussion

The main findings of the current study showed that maximal ball velocity was affected only after the most intense circuit, while accuracy was not affected in the protocol. The increased intensity corresponded to the expected decrease in duration in each circuit and the increase of fatigue, as demonstrated by HR, RPE, and lactate. Our results suggest that kicking performance (ball velocity) is only affected after high-intensity exercises. Lower exercise intensities do not affect accuracy or kicking ball velocity.

Parts of these results are in accordance with previous studies about the effect of high-intensity exercises on kicking soccer balls. The studies reported the possible negative effect explained by biomechanical and physiological causes such as generated muscle incapacity with a decrease in strength, reduction of movement stability (especially in knee and hip range of motion), or a decrease of limb velocity.[10,24–30]

A previous study[5] that researched the variations between different exercise intensities also reported a detrimental effect on passing skill performance after high levels of localised fatigue. These findings are consistent with soccer-specific research,[31] which observed a detriment in the psychomotor performance of players following exhausting levels of exercise.

However, contradictory results were found by McMorris et al.[20] considering passing skills. They found that performance in rest and high-intensity exercise did not differ. Also, Ferraz et al.,[11] according to the most recent fatigue theories and using a repetitive high-intensity protocol (exhaustion protocol), concluded that maximal ball velocity on kicking was also affected, but this effect was not linear or progressive and might be dependent upon factors other than those relating to physiology.[1,19] Another similar study[1] concluded that kicking accuracy and short passing ability were only minimally affected by high-intensity activities immediately post-exercise, but recovered thereafter in the case of kick.

The differences in the exercise protocols used in these studies may condition a comparative analysis of the results and can explain part of the contradictory outcomes. The majority of the studies pointed that high-intensity exercise was a potential negative factor on kicking performance due to fatigue. However, this potential was not found to be negative and could have been variable.[11] It is also known that, in successive repetitions at a high-intensity, the influence of fatigue may not always be the same; there may even be no practical effects on the performance of the kick, even if the player is exhausted.[11]

Another point of discussion is the comparison between the intensity of the first and second selected tempo. No differences in kicking performance (Fig. 3), time (Fig. 2), and lactate (Fig. 4) were found indicating the participants were pretty good in the perception of the prescribed intensity. Only the HR and RPE after the circuit was higher (Fig. 5), but that can be explained by the fact that after the first selected tempo, the participants were not so fatigued, while after the second tempo the participants have already performed several circuits with different intensities. Due to the random order of these intensities, some participants could have been more fatigued and were therefore not fully recovered from the previous one, which increased the HR and RPE more in the second time.[32]

However, it is also possible that at the second selected tempo, the pacing strategy used was more tiring (more intense), although it was not reflected in most of the remaining values; it was, however, reflected in HR and RPE, probably due to stronger overall coupling among the two.[32] Thus, it seems that, during the protocol, the perception of selected tempo changed and, according to recent studies, perhaps the player modulated their effort, and the auto-regulation became slightly more aggressive, even without significant results in kicking performance.[11,15,16,19] This finding shows a possible evidence that there may be mechanisms (not only physiological) that can influence players during exercise.

Regarding kicking accuracy, no effect was found. Conversely, some studies reported a negative effect on kicking accuracy in high-intensity efforts due to changes in coordination by inherent physiological causes:[26,29] approach speed, skill level,[1,33] blood lactate level and decreased muscle glycogen in connection with impaired neuromuscular performance affecting coordination and, consequently, soccer skills.[34] Otherwise, similar effects on kicking accuracy were found in a recent and related study,[1] which showed that soccer skill performance was only minimally affected by acute resistance exercise independent of intensity because knee extensor muscle strength remained unaffected during protocol application. In addition, Ferraz et al.[11] did not find any effect on kicking accuracy, which was similar to a study by van den Tillaar and Ulvik[35] that showed that kicking accuracy could only be affected when the main priority in instruction was upon hitting the target.

Future studies should focus upon kinematic analyses of coordination and strength patterns to investigate the changes that occurred after high intensity activities. It would give a better understanding about the possible impact of the mechanisms (not only physiological) that can influence the player during exercise, especially the possible role of the psychophysiological aspects that should continue to be explored, in relation to the high intensity exercises, especially in team sports such as soccer.

5. Conclusion

Kicking soccer velocity was conditioned by high-intensity exercises. Additionally, we concluded that low and moderate exercise intensities did not affect the performance of the kick, and the intensity of exercise did not influence accuracy. A possible negative effect of fatigue due to high-intensity exercises and possible changes related to patterns of coordination and strength were considered. Otherwise, it is possible that other mechanisms (not only physiological) could influence players during the exercises, but more studies are needed to confirm and develop this hypothesis.

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Authors' contributions

RF, RT, and MCM conceived of and designed the experiments; RF and RT performed the experiments; RF and RT analyzed the data; RF, RT, and MCM drafted the manuscript.

All authors read and approved the final version of the paper, and agree with the order in which the authors are presented.

Competing interests

The authors declare that they have no competing interests.

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