

Influence of warm-up duration on perceived exertion and subsequent physical performance of soccer players

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ABSTRACT: The aim of this study was to analyse the effects of three warm-up protocols with different durations in semi-professional soccer players. Fifteen semi-professional soccer players performed three warm-up protocols (Wup_{25min}: 25 min, Wup_{15min}: 15 min and Wup_{8min}: 8 min duration) on three different days. Before (pre-test) and after (post-test) each warm-up protocol, the players' physical performance (sprint, vertical jump and change of direction) was evaluated and all the players were asked to respond to the subjective scale of readiness to play a match. Also, after completing each warm-up protocol, all players responded to the rating of perceived exertion (RPE) scale. Although all protocols significantly improved the feeling of players being prepared to play the game ($p < 0.05$ or $p < 0.01$), after performing the Wup_{25min} protocol the players performed worse in the 10 m sprint ($p < 0.01$) and in the 20 m sprint ($p < 0.05$). However, the Wup_{8min} protocol significantly improved performance in both the 10 m sprint ($p < 0.05$) and the 20 m sprint ($p < 0.05$). In addition, with the Wup_{25min} protocol players stated a higher perceived exertion (RPE) ($p < 0.05$) than in the Wup_{15min} and Wup_{8min} protocols. The Wup_{8min} protocol was the only one that improved the acceleration ability of the soccer players in this study.

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INTRODUCTION

Soccer is a sport in which a multitude of explosive actions (accelerations, decelerations, kicking the ball, changing direction or jumping) are interspersed with less intense actions [1]. Specifically, soccer players perform around 100-150 pace changes (i.e. accelerations) during a match [2]. In addition, they cover a distance of approximately 170 and 260 m at sprint speed (> 25.2 km/h) and between 680 and 1050 m at high intensity (> 14.4 km/h) [3], although these results vary, among other aspects, depending on the position in the field of each player [4]. Therefore, soccer is an activity with a high physical requirement [5].

Due to the high physical demands of competition, the warm-up is especially relevant since it can influence sports performance and reduce the risk of injury [6]. In this sense, some authors have argued that the warm-up has a dual function, on the one hand, to prevent injuries and, on the other hand, to contribute to players being better prepared and achieving an improvement in performance during competition [7]. In order to achieve these effects, one of the objectives of the warm-up is to increase body temperature and activate the muscles involved in the most relevant actions in the competition [7]

by means of dynamic movements and progressive activity [8]. Some authors argue that the physical and physiological demands of competition should largely determine the content, duration and intensity of the warm-up [9,10,11].

With regard to the duration of warm-ups in soccer, previous studies have used warm-ups with different durations ranging from 5 min [12] to 35 min [13]. It has been shown that a proper warm-up should prepare the muscles to perform the physical exertion in competition causing the least possible fatigue [9] and that its minimum duration should be approximately 10 min for players to obtain the greatest possible benefit. Several studies have analysed this aspect in order to ascertain the effects of different warm-up protocols of different durations. It was observed that by applying two types of warm-up, one of 15-17 min and one of 20-22 min, which included dynamic stretching exercises, the players decreased their ability to sprint 20 m after both protocols were performed [14]. However, after a warm-up with a weighted vest, athletes improved running performance via leg stiffness and running economy [15]. In a recent study of semi-professional soccer players [16], the authors observed

that a pre-match warm-up of 25 min, despite improving players' perception of being prepared to play a game, decreased sprint performance over 10 m and 20 m. The players in this study reported high values of subjective perceived exertion (RPE) and RPE training load at the end of the warm-up protocol [16], which may suggest that the warm-up with a duration close to 25 min caused fatigue in the soccer players and consequently a decrease in their physical performance. Similar results were obtained in other studies carried out with soccer players, where it was also observed that with longer duration of warm-up the RPE was significantly higher than for the short warm-up [17-19]. Due to these contradictory results among the different studies and in order to determine whether a reduction in the duration of the warm-up may be more effective, it would be interesting to carry out further studies to analyse the effects of same-task warm-up protocols with different durations in soccer players. In this sense, this study could help resolve the issues raised by previous studies that used quite different protocols.

Therefore, the objective of this study was to analyse the effects of three warm-up protocols with the same tasks but with different durations (25 min, 15 min, 8 min) on the physical performance (acceleration, vertical jump and change of direction), the perception of being prepared to play a match and the perception of the effort in semi-professional soccer players.

MATERIALS AND METHODS

Subjects

Fifteen semi-professional soccer players (19-35 years) who competed in the Third Spanish Division participated in this study. All players were training four days a week and the training lasted

approximately 90 min. In addition, every weekend the team participated in an official match of the national league competition. The inclusion criteria for participating in the study were not to have been injured in the last 3 months and having participated in at least 85% of training sessions.

Procedures

The study was conducted during three regular team training sessions in consecutive weeks (always on Wednesdays). Reference was made to the standard warm-up made by the team before the official matches. Each week, the 15 participating players performed the selected warm-up protocol with only modification of the duration (i.e. Wup_{25min}, Wup_{15min} and Wup_{8min}). Therefore, the exercises performed in the three warm-ups were the same, but the duration of each warm-up was modified.

Before performing each of the warm-up protocols, 5 min of slow running was performed. The pre-test physical performance assessment (sprint, vertical jump and change of direction) was then performed. Once the pre-test was finished, players were asked to respond to the subjective scale of readiness to play a match. They then performed the warm-up in each case (25 min, 15 min and 8 min). Once each warm-up protocol was completed, all players responded again to the perception of being prepared to play a match and the RPE was administered to all players individually. Finally, 7 min after completing the warm-up protocol in each case, the players performed the physical performance tests (post-test) again (Figure 1). All players were familiar with the practice of the warm-up exercises and assessment tests as they were usually employed either in training sessions and team matches or in test protocols during the season.

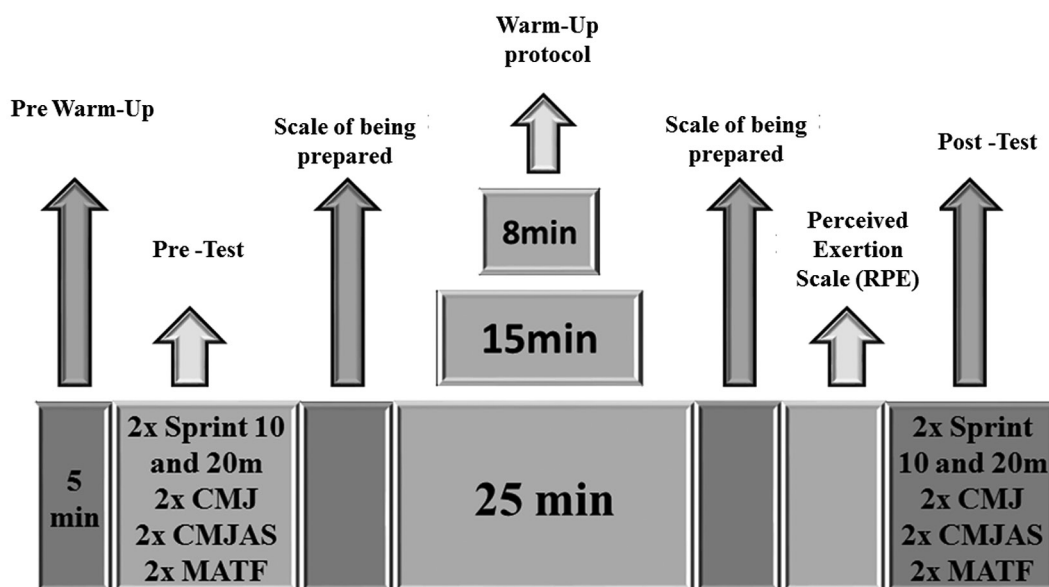


FIG. 1. Complete procedure of the study performed

Measurements

Scale of readiness to play a match: before each warm-up protocol players responded to a subjective scale of 0 to 10 previously used with soccer players [16] in which they were asked how prepared they felt to face a match, being 0 “not prepared at all” and 10 “perfect for playing”.

Straight line sprint test: the players completed 2 maximum accelerations of 20 m, with a rest of 3 min between each repetition, and the best time of each player was registered. The start was made from a distance of 0.5 m behind the first of the 3 photocells (Microgate Polifemo Radio Light, Bolzano, Italy) and when the player considered it appropriate The second photocell was placed at a distance of 10 m to calculate acceleration at the intermediate distance and and the third photocell was placed at 20 m [20].

Countermovement jump (CMJ): the CMJ test [21] was performed to evaluate lower body power. In addition, the players also made the CMJ with arm swing. The players repeated each type of jump on two occasions using the best of the jumps in each case for the statistical analysis. The rest interval between repetitions was 45 s. The flight time of the jump was recorded with a contact platform (Optojump, Microgate, Bolzano, Italy) [22].

Modified Agility Test Free: The guidelines to complete the route were followed as marked in the original Modified Agility test [23] (Figure 2): AB: Moving forward to touch cone B. BD: Moving to touch cone D, without exceeding the line of cones. D-C: Moving to touch cone C. C-B: Moving to touch cone B. B-A: Moving to the finish line. However, the players had to touch the top of the cones [24] and the

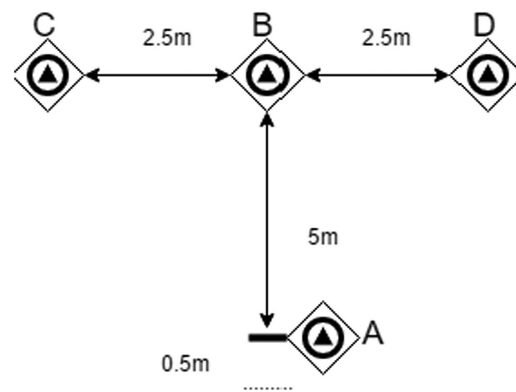


FIG. 2. Description of the Modified Agility Test Free (MATF)

movements could be carried out freely, that is to say, without having to run sideways or backwards [20]. The players repeated the test twice on the same pitch and with soccer boots, recording the best time. The rest between repetitions was 3 min. They started from a position 0.5 m from the photocell and when the player considered it appropriate. The time taken to complete the route was recorded by a photocell (Microgate Polifemo Radio Light, Bolzano, Italy) located on the start and finish line [25].

Rating of perceived exertion (RPE) scale: players were asked for their subjective perception of effort after each warm-up protocol was performed. The scale used to assess the RPE of athletes was the

TABLE 1. Characteristics of each of the warm-up protocols performed by the players.

Content	Wup _{25min}	Wup _{15min}	Wup _{8min}
Aerobic work and joint mobility (min)	0-3	0-2	0-1
Individual and collective technical exercises (min)	3-11	2-6	1-3
Free circulation with the ball (min)	3-5	2-3	1-1.30
Pass (min)	5-7	3-4	1.30-2
Ball driving (min)	7-9	4-5	2-2.30
Possession 4 vs.1 (min)	9-11	5-6	2.30-3
Static stretching (min)	11-13	6-7	3-3.30
Dynamic stretching (min)	13-14	7-8	3.30-4.30
Small sided game 5 vs. 5 (min)	14-16	8-9	4.30-5
Break (min)	16-17	9-10	5-5.30
Small sided game 5 vs. 5 (min)	17-19	10-11	5.30-6
Long passes (min)	19-23	11-13	6-7
Sprint starts (min)	23-25	13-15	7-8
Total time (min)	25	15	8

Wup_{25min} = warm-up of 25 minutes duration, Wup_{15min} = warm-up of 15 minutes duration, Wup_{8min} = warm-up of 8 minutes duration.

scale of 0-10 points [26]. This scale has been validated as an indicator of training intensity [27, 28].

Warm-up protocol: The typical warm-up protocol that the team made before the official matches was taken as a reference (Wup_{25min}). Using the same tasks, the time in each of them was reduced proportionally in both the Wup_{15min} and the Wup_{8min} (Table 1). The contents worked on in the protocol were: aerobic work and joint mobility, individual and collective technical exercises, static and dynamic stretching, two halves of a small sided game of 5 vs. 5, long ball passes and sprint starts. The warm-up durations were different. The first warm-up was 25 min (Wup_{25min}), the second 15 min (Wup_{15min}) and the third 8 min (Wup_{8min}). The specific contents of the warm-up and the different durations of each protocol are shown in Table 1.

Statistical analysis

The data are presented as mean values and standard deviation (mean ± SD). The Kolmogorov-Smirnov normality test was performed prior to the analysis of the data to verify the use of parametric statistics. To determine the differences between the results in the pre-test and post-test, a t-test for related samples was used independently in each of the protocols (Wup_{25min}, Wup_{15min} and Wup_{8min}). Effect size (ES) was calculated according to the method proposed by Cohen [29]. Effect sizes smaller than 0.2, in the range 0.2-0.5, 0.5-0.8 or greater than 0.8 were considered trivial, small, moderate or large, respectively. A two-way ANOVA (protocol x time) was used to analyse the interaction effect of the protocols (Wup_{25min}, Wup_{15min} and Wup_{8min}) and the test (pre-test and post-test). The relationship between the RPE, the feeling of being prepared for the match and the variables of the physical tests was calculated using Pearson's correlation (r).

TABLE 2. Results in the pre-test and post-test in the fitness test and in the perception of being prepared for the match after each of the warm-up protocols.

Protocol	Test	Pre-test	Post-test	ES	Mean Dif.	CL 95%	
						Lower	Upper
Wup _{25min}	10 m (s)	1.71 ± 0.09	1.78 ± 0.10	0.78 **	-0.07	-0.13	-0.02
	20 m (s)	3.01 ± 0.14	3.12 ± 0.20	0.78 *	-0.11	-0.20	-0.01
	10-20 m (s)	1.30 ± 0.06	1.33 ± 0.11	0.55	-0.03	-0.09	0.02
	CMJ (m)	0.45 ± 0.07	0.45 ± 0.08	-0.01	0.00	-0.04	0.04
	CMJAS (m)	0.60 ± 0.05	0.60 ± 0.05	-0.02	0.00	-0.03	0.03
	MATF (s)	4.96 ± 0.21	5.07 ± 0.36	0.51	-0.11	-0.25	0.03
	Prep	2.80 ± 1.61	6.27 ± 1.44	2.15 **	-3.47	-4.59	-2.34
Wup _{15min}	10 m (s)	1.76 ± 0.06	1.73 ± 0.08	-0.56	0.04	-0.00	0.07
	20 m (s)	3.08 ± 0.15	3.04 ± 0.16	-0.27	0.04	-0.01	0.09
	10-20 m (s)	1.32 ± 0.10	1.31 ± 0.09	-0.06	0.01	-0.03	0.05
	CMJ (m)	0.47 ± 0.04	0.47 ± 0.03	0.08	0.00	-0.02	0.01
	CMJAS (m)	0.62 ± 0.02	0.62 ± 0.02	0.09	0.00	-0.01	0.01
	MATF (s)	4.97 ± 0.20	4.87 ± 0.25	-0.48	0.10	-0.01	0.21
	Prep	2.54 ± 2.06	6.45 ± 0.93	1.89 **	-3.91	-5.72	-2.10
Wup _{8min}	10 m (s)	1.78 ± 0.07	1.72 ± 0.06	-0.77 *#	0.05	0.02	0.09
	20 m (s)	3.10 ± 0.13	3.00 ± 0.09	-0.72 *#	0.10	0.03	0.16
	10-20 m (s)	1.32 ± 0.07	1.28 ± 0.03	-0.50	0.04	-0.02	0.10
	CMJ (m)	0.47 ± 0.05	0.46 ± 0.06	-0.02	0.00	-0.02	0.03
	CMJAS (m)	0.61 ± 0.03	0.61 ± 0.04	-0.03	0.00	-0.02	0.02
	MATF (s)	4.83 ± 0.17	4.84 ± 0.22	0.07	-0.01	-0.09	0.06
	Prep	2.25 ± 1.75	5.62 ± 1.18	1.92 **	-3.38	-4.71	-2.04

Wup_{25min} = 25 minutes warm-up protocol, Wup_{15min} = 15 minutes warm-up protocol, Wup_{8min} = 8 minutes warm-up protocol, ES = effect size, Mean Dif. = Difference between averages, CL = confident limits, Straight line sprint test = 10 m, 20 m, 10-20 m, CMJ = countermovement jump, CMJAS = countermovement jump with arm swing, MATF = Modified Agility T-test, Prep = Perception of being prepared to face a match. * p < 0,05, ** p < 0,01, Significant differences between pretest and posttest. # p < 0,05, Significant differences in the two-way ANOVA (protocol x time).

For the interpretation of the results obtained in these correlations we used the values established by Salaj and Marcovic [30]: small ($r \leq 0.3$), moderate ($0.3 < r \leq 0.7$) and large ($r > 0.7$). Statistical analysis was performed with the Statistical Package for Social Sciences (version 23, SPSS Inc, Chicago, IL, USA). Statistical significance was defined as $p < 0.05$.

Ethics

Before starting participation in the study, written consent of the players was obtained after them being informed of the procedures, risks and benefits of the investigation. The design and protocol of the study conformed to the ethical standards established in the Declaration of Helsinki (2013) and were approved by the Ethics Committee for Human Research (CEISH) of the University of the Basque Country (UPV/EHU).

RESULTS

Table 2 shows the results obtained in the pre-test and post-test in both the physical condition variables and the one of readiness to play the match after each of the three warm-up protocols. As can be seen, with the Wup_{25min} protocol, the players showed decreased performance in both the 10 m sprint ($p < 0.01$, ES = 0.78, moderate) and the 20 m sprint ($p < 0.05$, ES = 0.78, moderate). With the Wup_{15min} protocol, no significant changes in physical performance were observed ($p < 0.05$). However, the Wup_{8min} protocol significantly improved performance in both the 10 m sprint ($p < 0.05$, ES = -0.77, moderate) and the 20 m sprint ($p < 0.05$, ES = -0.72, moderate). None of the warm-up programmes significantly improved CMJ vertical jump capability ($p > 0.05$, ES = -0.03 to -0.09, trivial), CMJ with arm swing ($p > 0.05$, ES = -0.02-0.08, trivial), or Modified Agility Test Free ($p > 0.05$, ES = -0.48 to -0.51, small to moderate). Regarding the feeling of being prepared to play the game, all protocols (Wup_{25min}, Wup_{15min} and Wup_{8min}) improved it significantly ($p < 0.05$ or $p < 0.01$, ES = 1.89-2.15, large).

In the Wup_{25min} protocol the players declared a higher RPE ($p < 0.05$, ES = -0.84 to -0.96, large) than in the Wup_{15min} (5.27 ± 1.71 vs. 3.82 ± 0.75 , ES = -0.84, Dif. (%) = 1.44, CI 95% = 0.14-2.76, $p < 0.05$) and Wup_{8min} (5.27 ± 1.71 vs. 3.63 ± 0.91 , ES = -0.96, Dif. (%) = 1.64, CI 95% = 0.20-3.08, $p < 0.05$) protocols. Although no significant difference was found in the RPE values between the Wup_{15min} protocol and the Wup_{8min} protocol, a small practical difference was found (3.82 ± 0.75 vs. 3.63 ± 0.91 , ES = -0.25, Dif. (%) = 0.19, CI 95% = -1.34-1.72, $p > 0.05$).

With regard to the correlations, no significant associations were found between the RPE and the change in the perception of being prepared to play the game or the perception of being prepared for the match in the post-test. Likewise, no moderate or high association was found between the RPE, or the perception of being prepared to play a match, and the change in physical performance (pre-test vs. post-test differences).

DISCUSSION

The objective of this study was to analyse the effects of three different warm-up protocols (25 min, 15 min, 8 min) on physical performance (acceleration, vertical jump and change of direction), perception of being prepared to play a match and the subjective perception of effort in semi-professional soccer players. Despite the importance of the duration of the warm-up for the physical performance of the players [7], few studies have analysed this aspect in soccer players. The results obtained in this study showed that, despite the fact that the three warm-up protocols gave players a better sense of being prepared for the match, only the Wup_{8min}, the shortest warm-up protocol, improved 10 and 20 m sprint performance. The 15 min protocol did not induce any change in the acceleration, vertical jump or change of direction ability, and the 25 min protocol induced a loss in acceleration capacity in the soccer players.

In soccer, warm-up protocols with different durations [14] ranging from 5 min [12] to 35 min [13] have been used. Although several studies have analysed the effects on soccer players' physical performance of short-duration and high-intensity warm-up protocols [30], longer protocols [31], or protocols with different types of tasks and durations [17-19,32,33], few studies have analysed whether the same type of warm-up (same exercises) with different durations could have different effects on the physical performance of soccer players [11,17]. In the present study, whereas the 25 min protocol caused a decrease in 10 and 20 m sprint performance and the 15 min protocol did not induce any change in acceleration, vertical jump or change of direction ability, the 8 min protocol was the only one that improved performance in the 10 and 20 m sprint. These results agree in part with those obtained by Andrade et al., [34] who observed that short-term specific [5 min of jumping exercises – 3x8 counter-movement jumps (CMJ) and 3x8 drop jumps from 60 cm (DJ60)] and combined (Run + Stretching + Jump) warm-up protocols increase slow stretch-shortening cycle (SSC) muscle performance, but only specific warm-up increases fast SSC muscle performance. However, after a long warm-up (35 min), a decrease was observed in players' vertical jump performance [12,16]. Based on the results obtained in this study, neither the 25 min protocol nor the 15 min protocol was effective in improving the performance of soccer players, while the protocol of a shorter duration was the most effective of the three warm-ups since it induced an improvement in acceleration capacity. These results also agree with the results obtained by Van den Tillaar and Von Heimburg [17], in which it was concluded that a short warm-up (10 min) is as effective as a long warm-up (20 min) for repeated sprint performance in national level soccer players. However, another study conducted with soccer players revealed that specificity is more important in a warm-up routine before sprint performance than the duration of the warm-up [19]. For this reason, it may be necessary to control not only the warm-up time but also the specificity of the tasks. Therefore, coaches should consider the possibility of designing warm-up protocols with durations closer to

8-10 minutes and with specific contents [19] in order to improve soccer players' acceleration after the warm-up.

Soccer teams typically perform warm-ups lasting approximately 20-25 min [32,34]. As observed in our study, RPE was higher in the 25 min and 15 min protocols compared to the 8 min protocol. These results coincide with those obtained in previous studies, where it was observed that, in the warm-up protocols of greater duration, the soccer players declared a greater RPE [17-19]. Possibly, the warm-up protocol of 25 min caused significant fatigue in the players and this could be the main reason for the reduction in sprint performance. On the other hand, prolongation of a specific component (i.e. static flexibility) could also have altered performance without fatigue. Sayers *et al.* [35] provide evidence that static stretching exerts a negative effect on sprint performance and should not be included as part of the preparation routine for physical activity that requires sprinting. However, the 8 min protocol, with a lower RPE (therefore possibly less fatigue) and less static stretching time caused an increase in performance in acceleration capacity. Previous studies indicate that the goal of a warm-up is to prepare the player for the game, improve their physical performance but not cause fatigue [7]. In the 8 min warm-up in the present study, in addition to improving acceleration capacity and producing a lower perceived load, a similar improvement was observed to that of the other warm-up durations in the perception of being prepared to play the game. Therefore, it appears that the warm-up protocol of 8 min was the most effective of the three. Coaches and physical trainers should consider the warm-up time in order not to cause a loss of physical performance in the players and to get an individual improvement in preparation for the competition. It must be taken into account that the three warm-up protocols used in this study (25 min, 15 min, 8 min) were preceded by 5 min of slow running. This measure was adopted with the aim of reducing the soccer player's injury risk in the pre-test. Therefore, the results must be considered with caution since the 5 min slow running performed before the warm-up protocols, even the activity

performed in the pre-test, could have influenced the results obtained in this study.

The present study is not without limitations. It is necessary to carry out more studies on this topic with a greater number of players and at different competitive levels (professional and high-level players) since our study was performed with semi-professional soccer players. In addition, it would be interesting to use different types of assessments or physical performance tests, in order to analyse whether there are variations in performance in other capacities (pre-post) depending on the duration of the warm-up. Moreover, this study did not analyse whether the warm-up volume can influence physical performance, external load (physical response) or internal load (physiological response) during a match/training session. Therefore, it would be interesting in future studies to analyse whether the duration of the warm-up, on the one hand, can affect the physical performance of the players during the match/training session and, on the other hand, can influence the injuries occurring during the match.

CONCLUSIONS

While the 25 min warm-up protocol caused a decreased performance in the 10 and 20 m sprint, the 8 min warm-up protocol was able to improve acceleration capability of the soccer players in this study. Longer warm-up protocols (25 min and 15 min) produced a higher RPE. Possibly a greater warm-up load may be associated with greater fatigue, an aspect that may have influenced the decrease in sprint performance. Since the shortest warm-up protocol (8 min) was the only one that caused an improvement in acceleration without detriment to the perception of being prepared to play a match, coaches should consider controlling the duration of the protocols used and adjusting warm-ups to last about 8 min.

Conflict of interest declaration: Ethical clearance was received for the research and the authors have no conflicts of interest to declare.

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