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Running Speed Loss Can Be Prevented with Passive Heat Maintenance before the Start of the Soccer Match

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Abstract: Maintaining the state achieved after the warm-up in modern soccer represents a significant problem. The main goal of this research was to determine the influence of a regular tracksuit on skin temperature and running speed during the pre-game routine. This study included 36 youth soccer players (15.61 ± 0.68 years, 175.16 ± 4.21 cm) divided into two groups. A two-way ANOVA was used with the level of significance set at <0.05. The main findings of this research indicated that skin temperature is reduced after the WU and is slower to be restored when players wear tracksuits. In addition, the results showed a significant treatment × time-point interaction effect for 10 [$p = 0.015$, $\eta_p^2 = 0.16$], 20 [$p = 0.001$, $\eta_p^2 = 0.26$], and 30 [$p = 0.005$, $\eta_p^2 = 0.20$] meter sprint tests. A significant treatment (experimental vs. control) main effect was observed for 10 m [$p = 0.042$, $\eta_p^2 = 0.35$], 20 m [$p = 0.020$, $\eta_p^2 = 0.55$], and 30 m [$p = 0.005$, $\eta_p^2 = 0.58$] sprint tests. Moreover, a significant sequence-trial interaction effect for 10 m ($p = 0.002$), 20 m ($p < 0.001$), and 30 m ($p < 0.001$) sprints was observed. However, the main effects of the sequence or trial factors alone were insignificant. It is concluded that regular tracksuits may have a beneficial influence on Ts loss and running speed. This research's most significant practical application is that it lasts for a short period of time and that it requires no extra effort.

Keywords: performance; team sport; training; youth

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1. Introduction

Since soccer is a highly demanding sport [1], warming up (WU) is widely accepted as a necessity because of its ability to elevate working temperature, enhance blood flow, and contribute to overall functionality [2]. Different WU protocols [3,4] can impact running speed [5,6], and practitioners are constantly searching for new methods for improving their athletes' performances. Since WU aims to prepare players for upcoming efforts, it is not surprising that negative or trivial results rarely occur [4,7] and are primarily those where static stretching is included [8].

In contrast to the WU, which has been mandatory since there has been an organized-sports system, a re-warm-up (RWU) during breaks has emerged as a relatively new method in soccer and has shown positive results [7]. Soccer benefits from RWU when used at halftime (HT), resulting in significant running-speed-loss reduction [2]. Mohr et al. [9] proved that RWU groups had higher muscle temperature (Tm) and lower skin temperature (Ts) and consequently had bigger sprint capacity at the start of the second half. The best practical use is that it lasts a short amount of time and does not lead to fatigue [10].

The break at HT lasts 15 min and, as Lovell et al. [11] reported, the temperature can drop 1.5–2.0 °C during that period. This timeframe resembles the pre-game routine (active

period + 10–15 min passive period) and may present the same problem. As there is a ceremonial pause between WU and the start of official matches (lasting approximately 12 min) [12], there is a need for RWU right before the match starts. Since that condition is almost impossible to fulfill (because activities during breaks are planned), the only possible solution is to maintain the reached working temperature passively [13,14]. This state is mainly achieved with the help of heating garments, which are proven to maintain muscle and skin temperature [14,15] and prevent running-speed reduction [16,17]. Although a few papers [18–20] have shown positive results using heating garments at HT, there is a lack of evidence of such protocols prior to the start of the game [16].

According to previous research, running-speed loss can be reduced by heating garments after the WU and before the start of the game [17]. This method has become more commonly employed to preserve the WU effect. Cowper et al. [16] proved that even after 6 min of passive break Ts could decrease to baseline values. Complementary to this are the findings of Galazoulas et al. [21], which indicated that 10 min may be enough for running speed to drop by 3.9% ($p < 0.001$, ES = 0.84) and temperature by ~1.3% ($p = 0.004$, ES = 0.29). Faulkner et al. [14] supported these findings by recording less Tm in an experimental group (wearing a heating garment) compared to the control ($p < 0.01$). West et al. [22] provided the information that applying a heating garment during the post-WU period can offset the temperature drop significantly ($p < 0.001$), even as much as ~50%, and can, consequently, improve sprint ability [17].

Most of the previous research shows the need for passive heat maintenance for both HT [17] and pre-game breaks [23] because Tm and Ts change after a few minutes of passive rest [9]. Although some research did work on passive heat maintenance with specific heating garments [24], to the best of the author's knowledge, none of the previous research investigated the influence of regular tracksuits on skin temperature and running speed in soccer players in a period between the WU and the start of the match, which might have the same effect as the one at HT. Therefore, the primary goal of this research was to determine whether regular tracksuits are adequate for maintaining the achieved skin temperature and running speed.

2. Materials and Methods

2.1. Participants

This study included 36 youth male soccer players (15.61 ± 0.68 y, 175.16 ± 4.21 cm), members of the same team competing in a top youth division with a playing experience of 7.4 ± 2.1 y. The participants were divided into two groups based on the sequence of treatments received (experimental and control after two weeks (AB group) or vice versa (BA group)). The AB group (n = 18; mean age: 15.46 ± 0.66 years; mean height: 175.33 ± 3.74 cm; mean weight: 54.36 ± 9.78 kg) received the experimental treatment followed by the control treatment, whereas the BA group (n = 18; mean age: 15.75 ± 0.63 years; mean height: 174.12 ± 4.01 cm; mean weight: 55.42 ± 10.01 kg) received the control treatment followed by the experimental treatment. For the experimental treatment, the athletes wore a regular tracksuit during the passive break, whereas for the control, they wore standard playing jerseys. The athletes remained seated during the passive break in the experimental and control treatments. To be included, athletes had to fulfill the following criteria: They were healthy, without any significant injury in the last month, were not involved in vigorous physical activity, and did not take caffeine or alcohol 24 h before testing. In addition, they maintained their regular nutritional intake for 48 h before the testing. All of the players wore regular soccer jerseys and soccer boots. The testing was carried out at the end of the competitive season in accordance with the Declaration of Helsinki and was approved by the Institutional Ethics Committee of the Faculty of Sport and Physical Education, University of Nis, Serbia (protocol code 04-387/2 and date of approval 27 March 2023). Written consent was obtained from each participant's parents/guardians, since they were all underage.

We calculated the total sample size using G-power (version 3.1.9.4) based on the procedure suggested by Faul et al. [25]. To determine the required sample size, we used an

a priori F-test with the following parameters: an effect size of 0.15, α error of 0.05 ($p < 0.05$), a power of 0.90 (1–β), two groups, and two measurements for running speed (or three measurements for Ts) with a correlation of 0.9 among repeated measures. The G-power suggested that 26 participants divided into two groups would be suitable for this design.

2.2. Research Protocol

The authors received a list of participants and verbally informed them of the testing and WU protocol the day before testing. Participants were randomly assigned to one of two groups using https://www.random.org/integers/ (accessed on 28 March 2023). Participants' height and body mass were measured in the dressing room, but WU, Ts measurement, and running speed were performed outside. Following the WU protocol, participants instantly came to a complete standstill and their Ts was re-recorded, after which they proceeded to the running-speed test in the predetermined order.

Given that it took 3–4 min to measure all players' Ts and running speed, they all proceeded with light exercises to maintain their muscle tonus while waiting for their turn. The assumption that this time frame did not significantly affect abilities can be justified by Turner et al. [26], who indicated that performances may be even greater 2–4 min after a WU that included post-activation performance enhancement (PAPE). Since similar exercises to those suggested when performing potentiation that could cause the PAPE effect were implemented during the WU, it was expected that the performance would not change in such a short period of time. The trained personnel measured a 12 min break after the first participant completed both tests. The participants from EG put on tracksuits immediately after the WU procedure, and after a 12 min break, the Ts and running speed were measured again. Given that the stopwatch was turned on immediately after testing the first participant and that everyone continued with light exercises until their turn, all participants had the same 12 min break (see Figure 1).

2.3. Procedures

2.3.1. Anthropometry Measurements

Participants' body height was measured in the dressing room on a flat, firm surface without shoes and with the head in a position that fulfilled the Frankfurt horizontal requirement using a Martin anthropometer, GPM 101 (GPM GmbH Switzerland, Susten, Switzerland), accurate to 0.1 cm. The examiner stood on the participant's left side, placed the anthropometer vertically along the back of the body, and then lowered the slider to the top of the head [27]. Body mass was measured with a bioelectrical impedance Omron BF511 (Omron Healthcare Co., Ltd., Kyoto, Japan), with an accuracy of 0.1 kg. Participants stood barefoot upright, were minimally clothed, and had their arms by their sides. The reliability and validity of the Omron BF511 bioelectrical impedance were confirmed by Dehghan and Merchant [28].

2.3.2. Warm-Up Protocol

In practice, a WU of 25–40 min is generally accepted [1,9] but is shown to be counter-productive [29], as it can significantly deplete energy reserves and raise body temperature too much [30]. Therefore, a WU that did not exceed 20 min was used, and the protocol was the same for all participants and was designed according to the athlete's usual WU practice. The WU included 5 min of moderate-intensity running with mobility exercises of all extremities on an area of 5 × 15 m without a ball (i.e., lateral movements, jumps, backward movement) and with a ball (passing, juggling, perception with teammates). Next, dynamic stretching for 4 min was implemented, where the movement pattern was the same for all exercises. Then, the players were divided into teams (5 vs. 5) to play small-sided games for 2 × 3 min on an area of 12 × 20 m, where the goal was to introduce the players to the game's intensity. The last WU part with a ball was shooting at the goal (from the ground, return balls, half-volleys, volleys) carried out for 2 min, followed by progressive sprint exercises (2–3 m) lasting 1 min (frontal skip and run, side skip and run, skip with

180 degree turns and run). All exercises were divided with 0.5 min breaks to prepare for the next one. Since the average passive break period without any activities before professional soccer games is measured as 12 min [12], this is the exact time players remained seated after the WU.

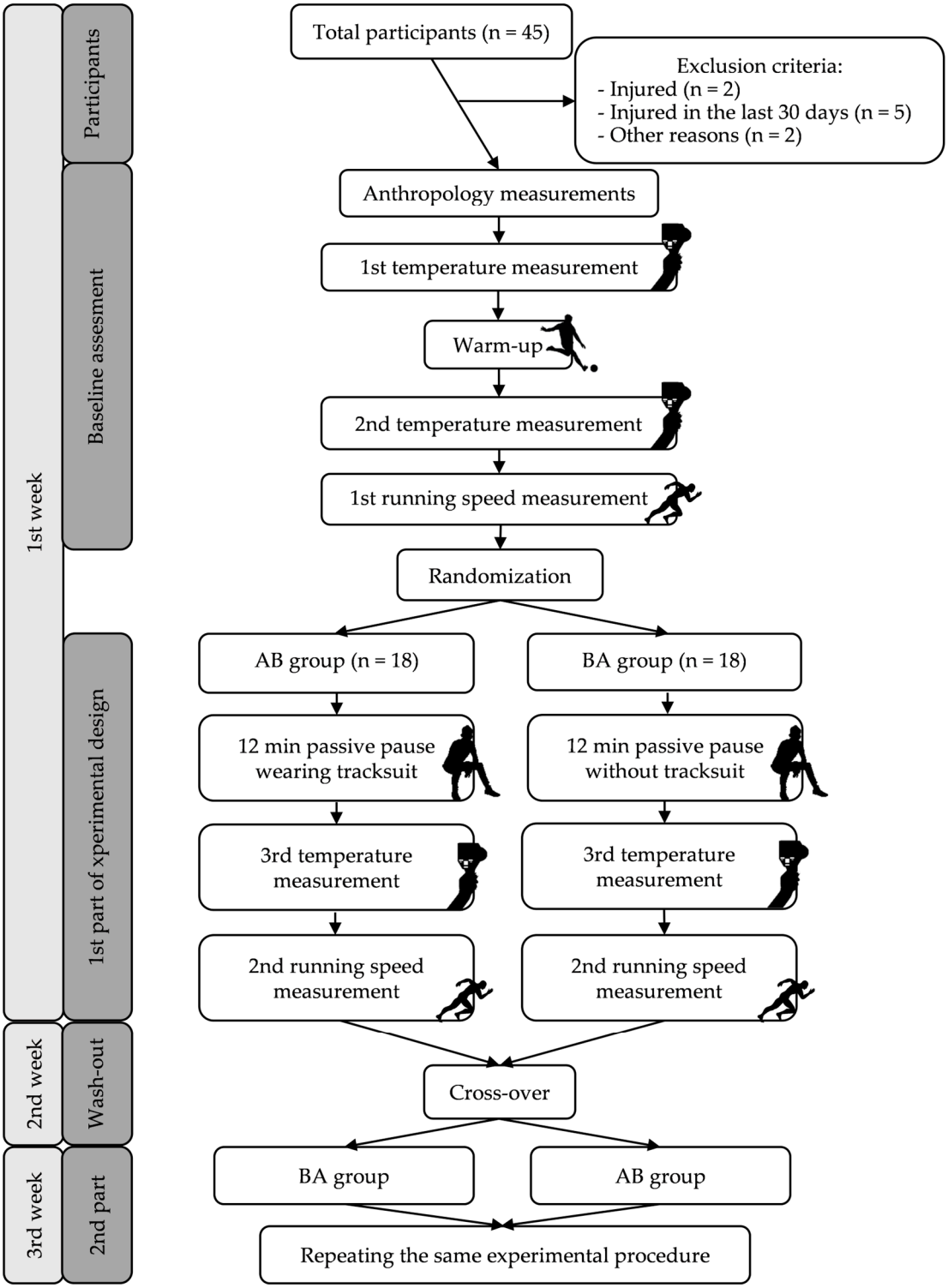

Figure 1. Flowchart for the study design and the participant screening.

2.3.3. Skin-Temperature Measurement

An Infrared Thermal Imaging Camera E30 (FLIR Systems, Täby, Sweden) was used, with a thermic sensibility of less than 0.1 °C and an accuracy of ±2% from the registered temperature. Following the warm-up, the players positioned themselves in front of a 2 × 2 m neutral white background wall to avoid direct sunlight that could affect the measurement outcome. Before measuring the skin temperature, the participants' legs were wiped with a towel to remove sweat, water, and any potential cream or lubricant. The camera was set 1.5 m away from the players and pointed in the middle of the m. vastus lateralis. Both tests were conducted in the morning (10 am–11 am) on an artificial-grass pitch with an approximate outside temperature of 25–27 °C.

2.3.4. The Running-Speed Assessment

In order to estimate the speed, a test of straight running at 30 m was used, measuring the split times at 10, 20, and 30 m with four Witty photocell gates (Microgate, Bolzano, Italy) positioned at the starting, 10 m, 20 m, and 30 m lines, with an accuracy of 0.01 s automatically stored on the computer. Players positioned themselves in a high start position with one foot just behind the starting line and ran the marked distance at maximum speed. During the trial, participants were verbally encouraged to maintain maximal effort until the end to avoid attenuating the results.

2.4. Statistical Processing

Statistical analysis was performed using the SPSS statistics program (version 26.0; BMI Inc., Chicago, IL, USA). A descriptive statistic was provided for all tested variables. The Kolmogorov–Smirnov was used to determine the normality of distribution and a two-way repeated-measure ANOVA (treatment [experimental, control] × timepoint (baseline, following warm-up, final) for the temperature and (treatment [experimental, control] × timepoint (following warm-up, final) for the running speed was used to determine the interaction effect between independent variables. A carry-over effect was examined by conducting a repeated-measure ANOVA (treatment sequence [AB, BA] × treatment (treatment A, treatment B) to determine the interaction effects between independent variables. Post-hoc pairwise comparisons were conducted using the Bonferroni correction to adjust for multiple comparisons. The effect-size criteria were as follows: 0.2 for trivial effects, 0.2–0.6 for small effects, 0.6–1.2 for moderate effects, 1.2–2.0 for large effects, and >2.0 for very large effects [31]. The alpha level was set at 0.05.

3. Results

Table 1 presents descriptive statistics for skin temperature and running speed for the study's first and second weeks. The table shows mean values and standard deviations for each measure, including baseline values, post-warm-up values, and values measured after 12 min of recovery.

In the first week, the mean skin temperature for both the AB and BA group decreased after the warm-up, then increased slightly during recovery. For running speed, there was an increase in the mean for 10 m, 20 m, and 30 m sprints after the recovery compared to post-warm-up times for both the AB and BA group.

In the second week, the mean skin temperature for both the AB and BA group decreased after the warm-up, then increased slightly during recovery. For running speed, there was an increase in the mean for 10 m and 20 m sprints after the recovery period compared to post-warm-up times for both AB and BA groups. However, the mean time for 30 m sprints decreased after recovery compared to post-warm-up times for both the AB and BA group.

The two-way ANOVA (repeated-measure design) showed a significant treatment–time-point interaction effect for the 10 [F (1, 35) = 6.55, p = 0.015, η_p^2 = 0.16], 20 [F (1, 35) = 12.03, p = 0.001, η_p^2 = 0.26], and 30 [F (1, 35) = 8.88, p = 0.005, η_p^2 = 0.20] meter sprint tests. When we observed the pairwise comparisons of simple main effects, it was evident

that the interaction effect of response variables differed between treatments. A similar pattern emerges in all response variables, where baseline values did not significantly differ from those after 12 min following experimental treatment. Conversely, baseline values significantly differed from values after 12 min following the control treatment, indicating a decay in performance (see Figure 2).

Table 1. Descriptive statistics for skin temperature and running speed.

	1st Week						
	Mean ± SD for AB			Mean ± SD for BA			
	Baseline	**Post-WU**	**After 12**	**Baseline**	**Post-WU**	**After 12**	**Total**
Ts (°C)	32.08 ± 0.80	31.49 ± 0.65	31.72 ± 0.69	32.20 ± 0.76	31.59 ± 0.72	32.08 ± 0.71	31.86 ± 0.75
10 m (s)		1.82 ± 0.05	1.83 ± 0.09		1.87 ± 0.09	1.92 ± 0.08	1.87 ± 0.07
20 m (s)		3.15 ± 0.12	3.18 ± 0.17		3.21 ± 0.015	3.29 ± 0.15	3.21 ± 0.14
30 m (s)		4.40 ± 0.19	4.46 ± 0.25		4.48 ± 0.25	4.61 ± 0.24	4.48 ± 0.23
	2nd week						
	Mean ± SD for AB			Mean ± SD for BA			
	Baseline	**Post-WU**	**After 12**	**Baseline**	**Post-WU**	**After 12**	**Total**
Ts (°C)	31.94 ± 0.80	31.56 ± 0.69	31.81 ± 0.72	32.21 ± 0.56	31.84 ± 0.49	32.01 ± 0.44	31.89 ± 0.66
10 m (s)		1.84 ± 0.06	1.87 ± 0.08		1.86 ± 0.09	1.85 ± 0.09	1.85 ± 0.08
20 m (s)		3.20 ± 0.11	3.26 ± 0.25		3.21 ± 0.13	3.19 ± 0.13	3.21 ± 0.12
30 m (s)		4.51 ± 0.18	4.62 ± 0.25		4.46 ± 0.22	4.43 ± 0.21	4.50 ± 0.21

Legend: baseline—pre-warm-up period; post-WU—post-warm-up period; after 12—measurement after 12 min of passive break; Ts—skin temperature; (°C)—degrees Celsius.

A significant treatment (experimental vs. control) main effect was observed for the 10 m [F (1, 35) = 4.45, p = 0.042, η_p^2 = 0.35], 20 m [F (1, 35) = 6.00, p = 0.020, η_p^2 = 0.55], and 30 m [F (1, 35) = 9.16, p = 0.005, η_p^2 = 0.58] sprint tests. Moreover, baseline-measurement responses significantly differed from responses after 12 min for the 10 m [F (1, 35) = 9.63, p = 0.004, η_p^2 = 0.17], 20 m [F (1, 35) = 18.41, p < 0.001, η_p^2 = 0.36], and 30 m [F (1, 35) = 12.88, p = 0.001, η_p^2 = 0.32] sprint tests.

Additionally, a two-way ANOVA (2 × 3 design) showed no significant treatment × time-point interaction effect for Ts [F (1, 35) = 0.18, p = 0.731, η_p^2 = 0.01]. The treatment (experimental vs. control) main effect for Ts [F (1, 35) = 0.13, p = 0.721, η_p^2 = 0.02] was also insignificant. However, baseline-measurement responses significantly differed between time points [F (1, 35) = 40.36, p < 0.001, η_p^2 = 0.51]. By observing pairwise comparisons of simple effects, it was evident that skin temperature significantly dropped following the warm-up protocol and significantly rose following the 12 min of passive rest for both experimental and control treatments. Interestingly, the skin temperature remained significantly lower after 12 min of passive rest compared to baseline values following the experimental but not the control treatment.

Moreover, a repeated-measure ANOVA (2 × 2 crossover) showed a significant sequence × trial-interaction effect for 10 m [F(1,17) = 14.19; p = 0.002], 20 m [F(1,17) = 24.99, p < 0.001], and 30 m [F (1, 17) = 18.86, p < 0.001] sprints. The pairwise comparisons of simple main effects revealed that the interaction effect of response variables differed between the treatment sequences, indicating some carry-over effects where the experimental treatment was more beneficial following the BA sequence (see Figure 3).

However, the main effects of the sequence or trial factors alone were insignificant. The results showed an insignificant trial (first vs. second) main effect for the 10 m [F (1, 17) = 1.06, p = 0.317, ηp^2 = 0.05], 20 m [F (1, 17) = 0.19, p = 0.636, ηp^2 = 0.02], and 30 m [F (1, 17) = 0.05, p = 0.830, ηp^2 = 0.002] sprint tests. Likewise, the sequence (AB vs. BA) main effect proved to be insignificant for the 10 m [F (1, 17), p = 0.067, ηp^2 = 0.26], 20 m [F (1, 17) = 0.34, p = 0.569, ηp^2 = 0.06], and 30 m [F (1, 17) = 0.19, p = 0.672, ηp^2 = 0.02] sprint tests.

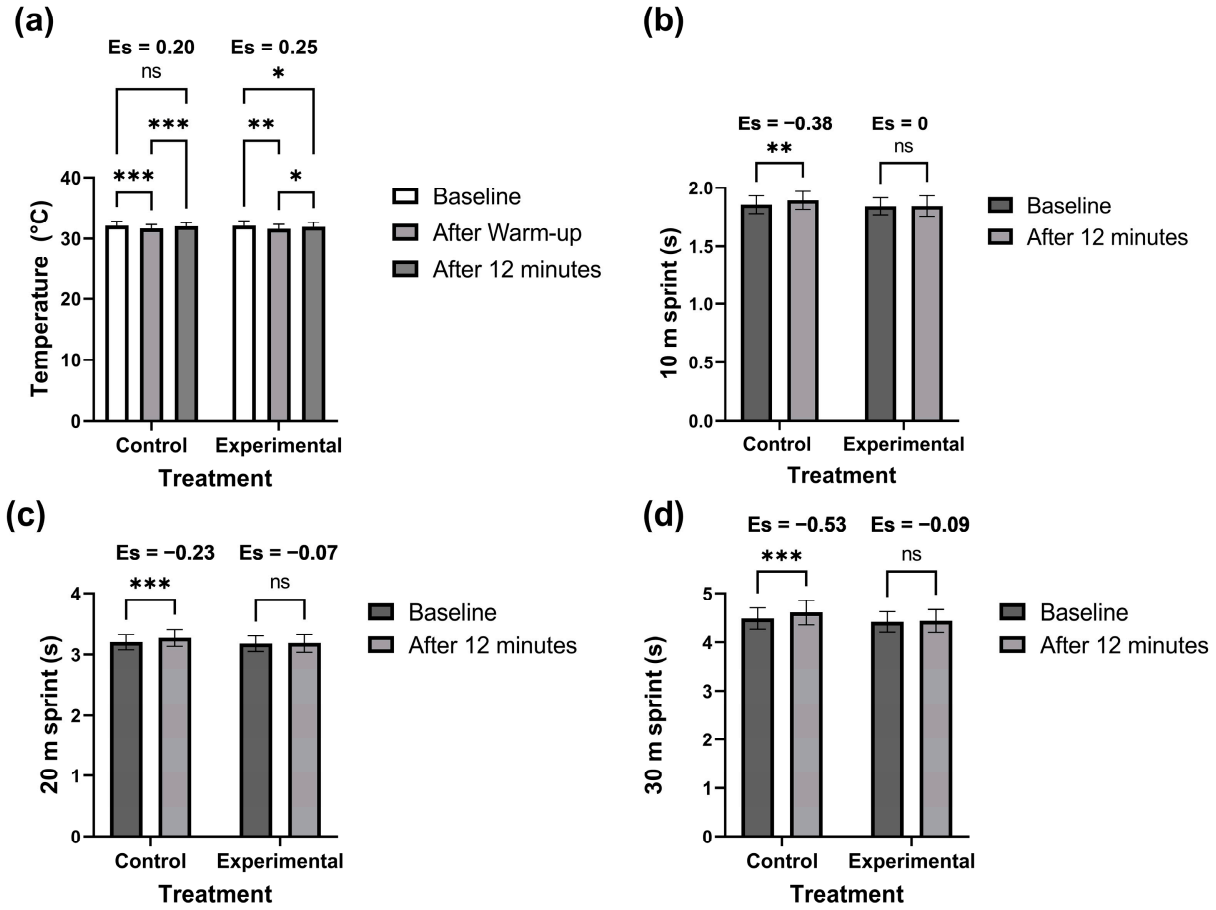

Figure 2. Bar plots showing the treatment × time-point interaction effect on skin temperature and sprint performance (2 × 2 repeated-measure ANOVA). The separate panels represent skin temperature (**a**) or different sprint distances of 10 m (**b**), 20 m (**c**), and 30 m (**d**), whereas the x- and y-axis indicate treatment (control and experimental) and the respective outcome variable (in Celsius or s). Error bars depict the standard deviation of the mean. Asterisks denote significant differences between treatments (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

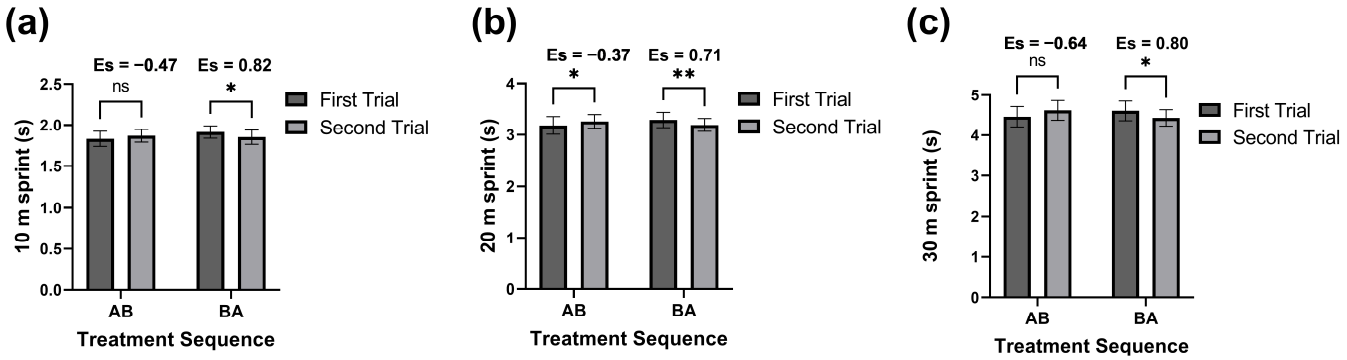

Figure 3. Bar plots show the treatment × trial interaction effect on sprint performance across different distances (10 m, 20 m, and 30 m). The data were analyzed using a 2 × 2 crossover design to explore the carry-over effect. The separate panels represent different sprint distances of 10 m (**a**), 20 m (**b**), and 30 m (**c**), whereas the x- and y-axis indicate the treatment sequence (AB and BA) and the respective outcome variable (in seconds). Error bars show the standard deviation of the mean, and asterisks denote significant differences between treatment sequences (* $p < 0.05$, ** $p < 0.01$).

4. Discussion

This research aimed to determine changes in skin temperature during the pre-soccer-game routine and to inspect the efficiency of regular tracksuits on Ts and running-speed preservation. The main findings indicate that tracksuits influence Ts, thus preventing players from significantly losing running speed.

We found no significant interaction effect between treatment and time point in Ts. However, a significant main effect of the time point indicated that skin temperature changed over time, regardless of the applied treatment. Pairwise comparisons of simple main effects showed that skin temperature significantly dropped following the warm-up protocol and significantly rose following the 12 min of passive rest for both experimental and control treatments (see Figure 2). Interestingly, the skin temperature remained significantly lower after 12 min of passive rest compared to baseline values following the experimental but not control treatment, indicating that the experimental treatment may have affected thermoregulation, which could have contributed to the maintenance of sprint performance over time.

A possible explanation for the observed skin-temperature drop is the concept of blood-flow redistribution. During exercise, blood flow is directed toward the working muscles, whereas blood flow to other tissues, including the skin, may be reduced. This redistribution of blood flow may be a mechanism to improve muscle oxygenation and nutrient delivery. Following exercise, blood flow may remain directed to the muscles, which temporarily reduces skin temperature as blood is retracted from the skin. Mohr et al. [9] proved that Ts, like Tm, may be a good indicator of athletes' preparedness for maximum effort, but, in contrast to rising Tm, Ts decreases due to vasodilatation [32]. The results presented in this study showed no significant main effect for temperature (p = 0.691). Although a 0.49 °C (~1.3%) drop in Ts is not statistically significant, any difference in sports can be beneficial. These results were confirmed by Fröhlich et al. [33], who recorded a drop in leg Ts of 1.1 degrees (3.6%). These findings proved that Ts decreased regardless of the WU protocol. In contrast are the findings of Rodriguez-Sanz et al. [34], where the results of Ts were provided for the region of interest (ROI), which included the gastrocnemius and Achilles tendon. This mismatch can be explained by the fact that the skin is thinner in that region and the inside structures have more influence on the skin surface due to the lesser interference of subcutaneous fat [35]. At the end of the passive break, Ts was increased, and that change was more considerable following the control treatment compared to baseline values (effect sizes were 0.25 and 0.20 for the experimental and control treatments, respectively; see Figure 2). Ts tend to resume baseline values during the break but are less likely to be entirely restored if participants wear some heating garments [36]. Soo et al. [37] also confirmed that participants wearing a blizzard blanket during the passive break showed a significantly lower increase in Ts than the control group during the first 8 min. The results after that point are unclear because Ts tended to restore evenly in both groups after that period regardless of whether they wore a jersey or used some form of heating garments. However, our research showed positive results (lesser increase in Ts) in participants wearing tracksuits, even after a 12 min passive break. Since none of the previous research had the crossover design, it is impossible to compare the results precisely. However, Faulkner et al. [14] provided evidence that wearing tracksuits during the WU (36.9 ± 0.3 °C) and the break period (37.0 ± 0.2 °C) can diminish the Tm loss and presumably prevent a substantial Ts increase compared to a control group (36.6 ± 0.3 °C). Although more research must be conducted to underpin strategies to maintain Ts, the evidence from this and previous studies is promising and can provide a good baseline for practical application.

Furthermore, Ts and Tm are associated with running speed and can provide practical benefits for tracking overall player preparedness [38]. The results provided in this research showed no statistically significant main effect in 10, 20, and 30 m split times (p = 0.202; 0.636; 0.825, respectively) between treatments. In addition, there was no difference in sequence order for the 10, 20, or 30 m times (p = 0.494, 0.682, and 0.764, respectively), but the interaction effect between treatment and sequence was statistically significant for all

split times ($p < 0.05$). Research on speed preservation using heating garments is available for various sports. Wilkins and Havenith [36] conducted a study with swimmers and confirmed that swimming speed could be significantly preserved with the help of electric heating, resulting in the 50 m freestyle improving by 1.01% in the male group and by 0.38% in the female group. Faulkner et al. [14] confirmed these claims and concluded that Tm decline could be attenuated and sprint-cycling performance could be improved after the passive period in EG compared to CG ($p < 0.001$). However, Goh et al. [13] suggested that running speed could be significantly influenced by heating garments when the outside temperature was lower (10 °C), but this was not the case when the research was conducted during warmer conditions (32 °C) ($p < 0.01$). Our research was conducted during relatively warm weather (25–27 °C), so more evidence is warranted to draw decisive conclusions since outside temperature may have influenced Ts preservation.

Although the experimental condition proved effective, we should explain some carry-over effects that may raise concerns about our findings. For example, the experimental condition's effects seemed more beneficial following BA than the AB sequence for all outcome variables (10, 20, and 30 m sprint).

It might be that the participant's perception of the tracksuits was influenced by the order in which they were introduced to treatments. We assumed that participants following the BA sequence may have had a more robust perception of the benefits of the experimental tracksuit because it may have been presented as an improvement over the control condition. Although we did not provide any information to participants regarding the benefits of either treatment, previous knowledge and beliefs could attenuate the overall performance outcome. That may have affected sprint performance to be better in the experimental condition compared to the group that followed the AB sequence. Conversely, if participants received the experimental treatment first (in the AB sequence), they may have had higher expectations and perceived the control condition as less effective, leading to poorer sprint performance in the control condition compared to the experimental condition. De la Vega et al. [39] argued that a placebo effect may positively influence sprint performance. However, we cannot be entirely confident that the placebo effect induced a carry-over effect since we did not control for this particular confounding factor. Nonetheless, our study provides strong evidence concerning the preservation of Ts during the experimental condition, regardless of sequence and trial, since it proved more beneficial to sprint performance than the control.

There are a few limitations to this research. The main limitation is that it was conducted during relatively warm weather, which could have interfered with Ts measurements, and the outcome-variable could have been different during cold weather, where passive rest could have had a more significant impact on performance. The second limitation is that Ts and Tm measurements and their influence on various skills and abilities should be explored. Moreover, the timing of the trial may have contributed to the carry-over effect. The first measurement occurred shortly before the last game of the season, when the players had to be in peak shape. The second part of the test occurred ten days after the previous game, when the training intensity had dropped to a no-longer-competitive level.

Moreover, although this study did not observe psychological factors, future research could examine the placebo effect that the equipment used may have had on participants. Specifically, our study lacks control over the participants' previous knowledge and beliefs, which may have influenced their perception of the treatments and their overall performance outcome. Finally, the order in which the treatments were introduced to the participants may have also affected their perception and subsequent performance, potentially confounding the results.

However, the strength of this research is the effectiveness of the applied warm-up protocol for match preparation and the examination of an affordable method that can provide practical benefits to coaches and athletes. Since small details often decide the winner in soccer, this research can provide additional insight into employing sound warm-up strategies that could benefit the outcome of the game.

5. Conclusions

This study can provide a novel approach to coaches and practitioners in various sports by gaining advantages over opponents. Based on our results, we can conclude that regular tracksuits benefit Ts and running-speed maintenance. Compared to studies conducted with electric blankets or heating garments, tracksuits are not the best option but can be an affordable replacement. Coaches must be careful when implementing this method since we observed outcomes during warm weather; future research must confirm the outcomes during the winter.

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