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Original article

Comparison of three types of warm-up upon sprint ability in experienced soccer players

Roland van den Tillaar *, Eirik Lerberg, Erna von Heimburg

Department of Teacher Education, Nord Trøndelag University College, Levanger 7600, Norway

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Abstract

Purpose: The study aimed to compare the effects of a long general warm-up, a long specific warm-up, and a short specific warm-up upon sprint ability in soccer players.
Methods: Twelve male soccer players (age: 18.3 ± 0.8 years, mean ± SD; body mass: 76.4 ± 7.2 kg; body height: 1.79 ± 0.05 m) conducted 3 types of warm-ups with 1 week in between: a long general warm-up, a long specific warm-up, and a short specific warm-up followed by 3 sprints of 40 m each. The best, average, and total sprinting times together with heart rate and ratings of perceived exertion were measured.
Results: The sprint times (best, average, and total time) were significantly better when performing a long specific or short specific warm-up compared with the long general warm-up (all $p < 0.05$). The received perception exertion was significantly lower during the specific short warm-up (4.92 ± 0.90) compared with the longer ones (6.00 ± 0.74 and 6.25 ± 0.87, respectively).
Conclusion: Specificity is more important in a warm-up routine before sprint performance than the duration of the warm-up.

Keywords: Duration; Performance; Received perception exertion; Running; Specificity; Total sprinting times

1. Introduction

Warming up is a procedure that is used in mostly all sports with the intention to gradually adapt the body physically and mentally for the main activity afterwards, to enhance this activity performance,[1−3] and to reduce the risk of injuries during that activity.[4,5] A warm-up is pretty much the same in team sports, like rugby, team handball, and soccer. It is often prescribed with a general cardiovascular warm-up of 10−20 min and stretching followed by a specific warm-up for that specific sport.[1,6,7]

A lot of studies have investigated warm-ups and their effects in different performances, which can be divided into performances of short duration (0−10 s), intermediate duration (10 s−5 min), or long duration (longer than 5 min).[4] Studies have manipulated duration[4,7,8] and/or intensity[9,10] to increase muscle temperature, maintain phosphate depot,[11] and performance. Other studies have investigated the effect of different rest protocols between warm-up and performance[12,13] or the content of the warm-up (active *vs.* passive, general *vs.* specific, with or without stretching).[2,4,7]

However, the effect of duration and/or specificity of the warm-up upon short duration performance such as sprinting is not investigated much.[7,14−17] All these studies used jogging or walking to stimulate the cardiovascular system as a part of the warm-up combined with some high-intensity activity later in the warm-up like heavy squats,[14] dynamic exercises like knee lifts[15,18] and running with weight vests.[14] Only small significant increases in sprint performance were found after these warm-up protocols (0.87%−0.94%). However, it is still not clear if a general warm-up from the start, like jogging for a duration of longer than 10 min, would have a more positive effect upon short performances like sprints than only a short specific warm-up. Taylor et al.[7] showed that using only a general and specific warm-up of around 10 min was as good as using a warm-up of 20 min, which included a phase of static or dynamic stretching, for repeated sprint performances. They concluded that it is more practical to complete the short warm-up consisting of a short cardiovascular part followed by a specific high-intensity activity, since this will release more time used to more important training skills in soccer. The question

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* Corresponding author.
E-mail address: roland.tillaar@hint.no (R. van den Tillaar).

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arises if it is necessary to have a general, cardiovascular part of the warm-up before conducting the specific part or if conducting only the specific part is enough for enhancing sprint performance in soccer players.

Therefore, the aim of the present study was to investigate the effect of specificity and duration of warm-ups upon sprint performance (40 m). It was hypothesized that specificity in warm-ups had a more positive effect than duration of warm-ups upon 40-m sprints.

2. Methods

2.1. Participants

Twelve experienced soccer players playing at the 3rd−6th division of the national league (age: 18.3 ± 0.8 years, body mass: 76.4 ± 7.2 kg, body height: 1.79 ± 0.05 m) participated in the study. The participants were fully informed about the protocol before the start of the study and an informed consent was obtained prior to testing from all participants, in accordance with the approval of the Regional Committee for Medical and Health Research Ethics and current ethical standards in sports and exercise research. The experiment was conducted at the beginning of the competition season in March−April. The tests were always conducted on the same day (Tuesday), place, and time of the day (8:30−10:00 a.m.), with the same researchers at each test with 1 week in between.[19] In addition, the participants were instructed to avoid strenuous training for 24 h and alcohol consumption at least 12 h and no food consumption 2 h before each test.

2.2. Design

To compare the effects of duration and specificity of warm-up protocols upon sprint performance, a repeated measurement design was conducted in which the participants performed 3 warm-up protocols with 1 week in between. To avoid a learning effect from occasion to occasion, a randomized cross over design was used. The independent variables were the type of warm-up (a short specific, long specific, or a long general) and the dependent variable was the 40-m sprint performance.

2.3. Procedures

On each occasion, the participants performed 1 of the 3 warm-up protocols followed by the 40-m sprint. The long general warm-up consisted of 10-min jogging at 60%−75% of maximal heart rate followed by 7 dynamic exercises for the shoulders, hip, knee, and ankle joints, starting with the shoulders and working downwards (Fig. 1). These dynamic exercises were performed 10 times each to increase the range of motion in each joint and to avoid the heart rate decreasing much in this period. These dynamic exercises were included to the protocol since earlier studies[7,18] showed that dynamic exercises did have a positive effect upon performance after and that the participants were familiar with these exercises. Prohibiting the participants from doing these dynamic exercises could have influenced their following sprint performances negatively. Since all 3 warm-ups were included in these exercises, no difference in performance due to these exercises was expected. After these exercises, the participant continued with jogging at 60%−75% of their maximal heart rate again for a total of 20 min from the start of the long general warm-up.

The 1st part of the long specific warm-up was the same as in the long general warm-up: 10-min jogging (60%−75%) and dynamic exercises. After this, 3 acceleration runs of 60 m were performed at 75%, 85%, and 95% of estimated maximal sprinting velocity with 60 s of rest in between. The warm-up finished with jogging at 60%−75% of their maximal heart rate for a total of 20 min.

The short specific warm-up consisted of 8 × 60-m runs with 60-s rest in between (10 min in total). The 1st 60 m was performed at a self-estimated intensity of around 60% of estimated maximal sprinting velocity. Every next 60 m was increased with around 5% until it reached 95% of maximal self-estimated intensity. In each rest period, 1 of the same 7 dynamic exercises as in the other 2 warm-up protocols was used.

After each warm-up protocol (20 min for the 2 long warm-ups and 10 min for the short warm-up) the participants had 3 min of active rest before they performed three 40-m sprints with 3 min in between each run. Forty meter sprints were

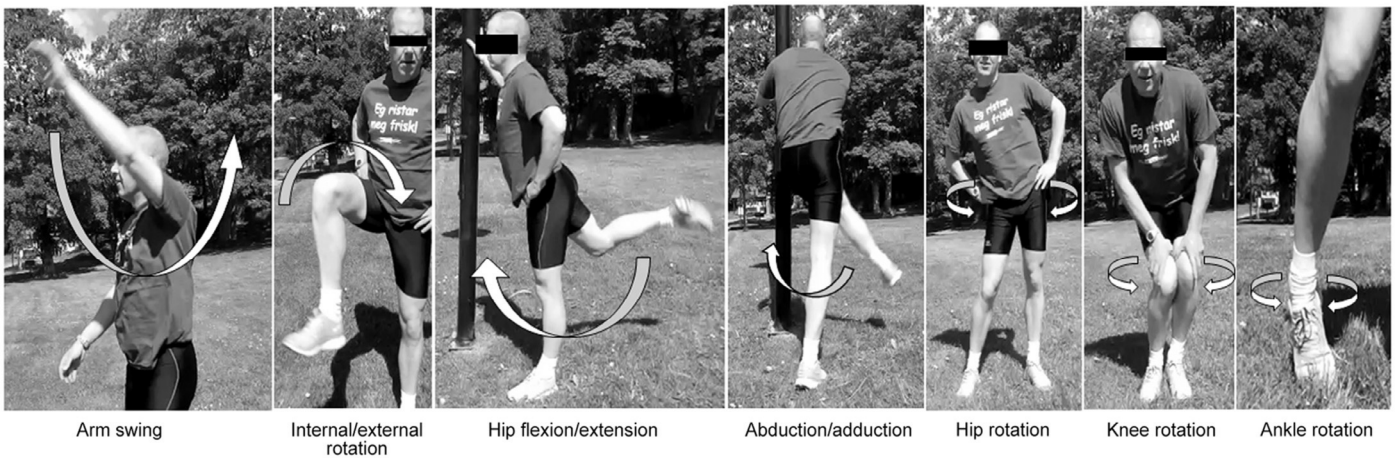

Fig. 1. Different dynamic exercises to increase the range of motion during the different warm-ups.

chosen since this is a regular test distance that distance soccer players often perform during training and competition.[20] Three minutes rest between each max 40-m sprint was given to assure that adenosine triphosphate and phosphate depots were full again.[12,13,21] Both the warm-up and the sprint test were performed on a tartan surface in an indoor soccer hall with the participants wearing their regular running shoes.

Each 40-m sprint was measured with 2 pairs of wireless photocells using a Brower Timing-TC system (Brower Timing Systems, Draper, UT, USA). The participants started 0.3 m behind the 1st beams, which were placed at a 0.3-m height. The last pairs of beams were placed at a 0.7-m height to avoid the participants throwing their arms or legs forwards to get a faster time. Sprint performance was tested as best, average, and total sprint time (of the 3 attempts). Time on each sprint was measured.

To be sure that the participants performed the warm-up at the prescribed intensity, a heart rate belt (Polar RS 400; Polar Electro Oy, Kempele, Finland) was used. Since no maximal heart rate was measured before the test, the formula 220 beat/min − age (years) of participant[22] was used as maximal heart rate to calculate the prescribed relative intensity of 60%−75%.

In addition, the received perception exertion (RPE) was measured on a Borg scale of 0−10 in which 0 indicated no exertion and 10 indicated maximal perceived exertion.[23] The RPE was asked straight after completion of each warm-up protocol to have an indication about each participant's subjective perception exertions of each warm-up protocol.

2.4. Statistical analyses

The effects of the 3 warm-up protocols upon the sprint performance were tested by a two-way analysis of variance (ANOVA) 3 (sprint times of Sprints 1−3) × 3 (short specific, long specific, and long general warm-up) with repeated measurements on both factors. When significant differences in sprinting times were found, a one-way ANOVA was conducted to locate eventual changes per condition. *Post hoc* comparisons with Holm−Bonferroni corrections were conducted to locate differences. Where sphericity assumptions were violated, Greenhouse−Geisser adjustments of the p values were reported. The criterion level for significance was set at $p < 0.05$. Effect size was evaluated with η^2 where $0.01 < \eta^2 < 0.06$, $0.06 \leq \eta^2 < 0.14$, and $\eta^2 \geq 0.14$ constitute small, medium, and large effects, respectively.[24] All results were presented as mean ± SD. Statistical analysis was performed in SPSS (Version 21.0; IBM Corp., Armonk, NY, USA).

3. Results

A significant effect of the warm-up protocol was found on sprint performance (F (2, 22) = 33.3, $p < 0.001$, $\eta^2 = 0.75$), but not for Sprints 1−3 (F (2, 22) = 9.1, $p = 0.42$, $\eta^2 = 0.08$). In addition, an interaction effect was found (F (4, 44) = 3.3, $p = 0.018$, $\eta^2 = 0.23$). A *post hoc* comparison showed that the 40 m sprint times (best, average, and total sprint times) were significantly longer after the long general warm-up compared to the other 2 warm-up protocols (Table 1). A one-way ANOVA showed that the average sprint time decreased between the 1st sprint and the 3rd one for the long general warm-up, while no significant changes were found for the long specific and short specific warm-ups (Fig. 2).

Table 1
Best, average, and total sprint times after each warm-up condition together with the ratings of perceived exertion (RPE) straight after the warm-up and 3 sprints average over all subjects (mean ± SD).

Parameter	Long general warm-up	Long specific warm-up	Short specific warm-up
Best sprint time (s)	5.48 ± 0.10*	5.36 ± 0.10	5.38 ± 0.09
Average sprint time (s)	5.52 ± 0.10*	5.40 ± 0.11	5.42 ± 0.09
Total sprint time (s)	16.56 ± 0.30*	16.21 ± 0.32	16.25 ± 0.28
RPE after warm-up	6.17 ± 0.83	6.33 ± 0.78	5.00 ± 0.74*
RPE after sprints	6.00 ± 0.74	6.25 ± 0.87	4.92 ± 0.90*

* $p < 0.05$, compared with the other 2 warm-up protocols.

In addition, the perceptual parameter, RPE, showed a significant effect of warm-up protocols (F (2, 22) = 19.9, $p < 0.001$, $\eta^2 = 0.64$). A *post hoc* comparison showed that RPEs after warm-up and after sprints were significantly lower when performing the short specific warm-up than performing the other 2 longer warm-ups ($p < 0.05$, Table 1).

4. Discussion

The purpose of the study was to investigate the effect of specificity/content and duration of warm-up upon sprint performance (40 m). The main findings were that the sprint times were better when performing a long specific or short specific warm-up (Table 1, Fig. 2), but the RPE was significantly lower when performing the short specific warm-up compared with the longer ones (Table 1).

The sprint times are comparable with earlier studies on soccer players of similar playing levels.[25,26] As hypothesized, specificity in warm-ups had a positive effect upon sprint performance. Simply conducting a long general warm-up that promotes the sympathetic activation of the cardiovascular system[6,7] and

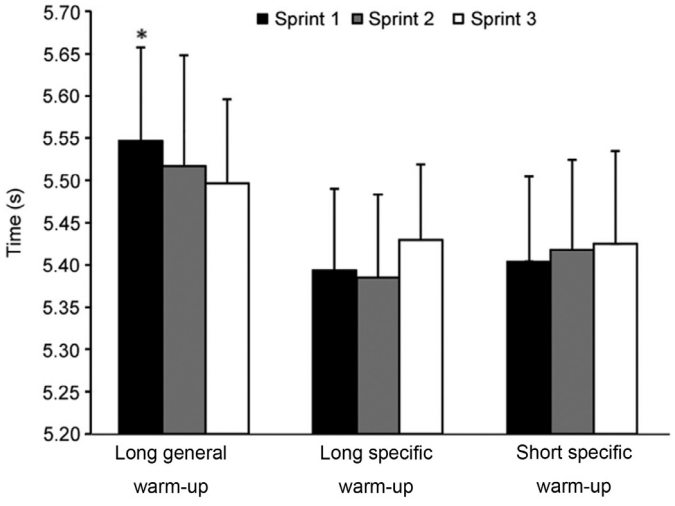

Fig. 2. Sprint times (mean ± SD) for each sprint after each warm-up protocol (long general, long specific, and short specific). *$p < 0.05$, compared with Sprint 3 in the long general warm-up.

thereby aiming to stimulate the following processes—muscle temperature, reducing muscle stiffness in muscles and joints,[9] shifting to the right in the force−velocity relationship and increasing metabolic reaction velocity[1,27]—is not enough to increase sprint performance maximally. One should also include specific runs that stimulate the activation of the performance, limiting muscles that are directly related to the coordination of sprints.[4,6] As shown after the long general warm-up, the participants decreased their sprint time from Sprints 1 to 3, indicating that they were not ready to sprint maximally during the 1st runs (Fig. 2). Still, the sprint time after the long general warm-up were not on the same level as the sprint time after the other 2 warm-up protocols. Thus, a minimum of at least 3 acceleration runs of 60 m at 75%, 85%, and 95% is needed (as performed with the long specific warm-up) to get the participants running faster, equal to the specific warm-up.[14−17]

In the present study, the sprint performance after the short specific warm-up (10 min) was the same as after the long specific warm-up (20 min), which could be explained by the fact that after 10 min after the start of an activity, muscle temperature reaches a plateau, and this does not increase more after these 10 min.[4,27] Consequently, warming up for a longer period than 10 min would not be beneficial for performance enhancement when looking only at muscle temperature.[1] Probably the intensity of the short warm-up was high enough to reach this increased muscle temperature plateau. Unfortunately, it was not possible to measure this possible increased muscle temperature due to insufficient equipment.

Possibly the long general warm-up of jogging at 60%−75% of their maximal heart rate for 20 min contributed to only an initial activation of the involved muscles of the total muscle load,[28] while the other 2 warm-up protocols, by including sprint runs of increasing activity, led to more increased muscle activity of the involved muscles.[29] In addition, the ranges of motion during these sprint runs will be more than during jogging and thereby tone muscle stiffness,[30] as well as transmission of nerve impulses,[31] and enhance the specific coordination of the involved muscles that is necessary for the sprints.[19,29] However, no electromyography or kinematics measurements were performed in the present study that could confirm this.

Another interesting finding was that the RPE values were significantly higher after the 2 long warm-ups and the sprints compared to the short specific one (Table 1), indicating that the participants felt that it was more exhaustive to perform after a long warm-up. This was in line with the study of Neiva et al.,[32] who found that RPE after warm-up was significantly less after a short warm-up compared to a longer warm-up. This was probably due to the duration of the warm-up (20 min *vs.* 10 min). The active rest period between the warm-up and the test was 3 min, a duration long enough to cover the fast component of the excess post-exercise oxygen consumption before test start and thereby almost full recovery. However, after the sprint test the RPE of the 2 longer warm-up protocols were still higher than after the short specific warm-up, indicating that participants experience longer warm-ups as more exhausting than short ones. This enhanced received perception of exertion could perhaps also influence the rest of a training session if this was performed before regular training sessions and could thereby influence training motivation.

In the present study, only the effect of duration and specificity of the warm-up was studied upon a short intense performance and not upon an intermediate or a long-term performance.[1] Neiva et al.[32] showed that in swimming with a time trial of 100 m (intermediate performance) also no differences were found in performance after a short warm-up compared to the regular one. However, for longer swimming performances they recommend a longer warm-up with proper intensity.[33] However, not many studies (especially in running) have investigated if it is necessary that for these intermediate and long-term performances the warm-up duration has to be longer than 10 min. In addition, it is possible that the short specific warm-up is too short and could cause possible injuries. However, in the present study no one experienced an injury or tendency to an injury after the short warm-up. Moreover, the participants reported that they were better prepared after the specific intermittent warm-up despite the short duration of 10 min. Since the participants performed this type of warm-up only once, it is not known if this short warm-up over a longer period would have a negative effect upon injuries and injury prevention. Thus, future studies should include this short specific warm-up protocol over a longer time to investigate if it does have an effect upon injuries.

5. Conclusion

The current study indicates that the duration of warm-ups did not have any effect upon sprint performance, as shown by the results that a short specific warm-up is as effective as a long specific warm-up for sprints in soccer. It is concluded that specificity is much more important in a warm-up before sprint performance than the duration of the warm-up. Both the long specific and the short specific warm-up resulted in better sprint time in experienced soccer players compared with just a general warm-up. Thereby, implementing this to regular training would result in less time used to warm-up, which could be used for more important training skills in soccer.

Authors' contributions

RvdT came with the idea and design, performed the statistical analyses, and wrote the manuscript; EL carried out the data collection and initial analyses and read the manuscript; EvH participated in its design and coordination and helped to draft the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

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