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Effects of Adding WB-EMS to the Warm-Up on Football Players Power Performance Tests: a Crossover Study

Auswirkungen der Zugabe von WB-EMS zum Aufwärmen auf Leistungstests von Fußballspielern: eine Crossover-Studie

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Summary

› **Background:** Football is an intermittent effort sport that demands high intensity power performance. To enhance this performance before training and competition, a short and intense warm-up is convenient. However, there is a gap between the performance reached in the warm-up and the performance needed during competition. Thus, the aim of this study was to analyze if adding WB-EMS to the warm-up increases or not football players performance.
› **Methods:** Twelve semiprofessional football players randomly performed 2 FIFA11+ protocol warm-up sessions, one wearing a WB-EMS suit and one without it. Player´s body temperature, blood lactate, and jumping and sprint abilities were measured.
› **Results:** Thermography showed that skin temperature (Tsk) significantly decreased after both protocols, and only left popliteal Tsk was significantly lower after WB-EMS warm-up protocol compared to NO WB-EMS warm-up ($p < 0.05$). Lactate was greater after No WB-EMS but not after WB-EMS warm-up. Sprint performance in 20 meters was significantly faster after WB-EMS compared to NO WB-EMS. No significant differences were found between trials in the rest of sprint and jumping abilities tests.
› **Conclusions:** Adding WB-EMS to the warm-up does not seem to increase body temperature, only left popliteal Tsk, and to improve acute sprint performance in semi-professional football players.

KEY WORDS:
Whole-Body Electromyostimulation, Sprinting Performance, Jumping Performance, Training

Introduction

Football requires players high intensity intermittent efforts throughout the match such as sprinting and jumping (8). Thus, it is imperative that the warm-up improves acute explosive performance. A recent review about warm-up in team sports (32) has pointed that shorter (i.e. 10 to 15 min) and intensive (i.e. ~90% of maximum heart rate and/or level 16 of rating of perceived exertion) warm-up gets better performance results. However, players are usually not ready for this kind of strenuous warm-up and typical tasks performed in real-world context are different than what is required.

The ideal warm-up should allow the athlete to attain an optimal muscle temperature range that limits fatigue as much as possible while maximizing performance (29). However, warm-up habitual routines in football typically include dynamic stretching, cardiovascular activation and high-intensity short-duration task (17). Although those strategies have been shown to improve team sports performance, especially when shorter and intensive strategies are applied (32), there is still a gap between the performance achieved in the warm-up and the performance needed in competition since soccer players require intermittent sprinting during matches (8). In addition, the transition time between the warm-up and the beginning of the match also leads to a performance impairment between warm-up and the competition (15).

In this line, previous studies have focused on adding different strategies to the warm-up in order to increased muscle stimulation and inducing a potentiating effect. A set of 5 repetition maximum leg press added to a standard warm-up protocol seemed to increase jumping and sprinting performance compare to small sided game (38). Also, whole body vibration of 50 Hz plus a 30% players body increased CMJ and 15 meters sprint performance compared to isometric exercise (28). On the other hand, the addition of post-activation potentiation exercise through explosive squats (1 m/s and 0.5 m/s speed movement) to a traditional warm-up did not improve RSA performance in football players of different competition levels (31). Despite better or worse results, these studies required specific apparatus that seem to be difficult to apply as a part of a warm-up protocol performed on a football field.

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Previous studies have reported that warming-up increases metabolic rate and muscle temperature as effective performance enhancement (22, 24). In this line, Infrared thermography has many applications in sports (23), among others to track the effects of the exercise along different moments of the training session (9). In particular, thermography has been previously used for evaluating the skin temperature (Tsk) response to the warm-up not only in athletes (1) but also in horses (21), but the effects are still controverted because some studies have reported increments of Tsk after warming up in Paralympic Powerlifting athletes (6), while Adamczyk and his collaborators obtained significant decreases in the Tsk after warming-up in decathletes (1).

A previous meta-analysis of EMS methods showed that this technology can be an effective tool for enhancing maximal strength, speed strength, sprinting and jumping performance in elite athletes (13). A subsequent study showed that WB-EMS effectively enhanced performance abilities, such as sprinting, jumping and kicking, in football players. In the study by Zink et al. (37), they did not find a significantly greater effect for the WB-EMS warm-up condition in golf players, when they separated athletes with high versus low swing speed, they observed improvements for the slower group. To our knowledge, no study has investigated the possibilities of adding WB-EMS to a football warm-up protocol. Hence, the aim of this study was to analyze the effect of adding WB-EMS to a warm-up protocol on football players performance abilities. We hypothesized that adding WB-EMS to warm-up would enhance players performance abilities.

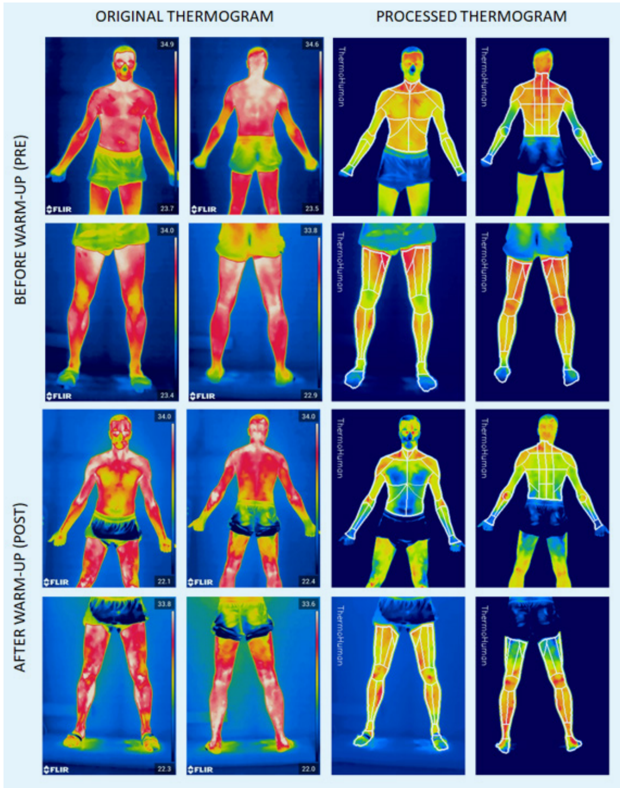

Figure 1

Original and processed thermograms representative of before and after warm-up temperature changes.

Materials and Methods

Subjects

Twelve semiprofessional football players from the same team agreed to participate in the study. They were 21.75±1.86 years old, their body weight was 71.58±6.86 kg and their body height was 178.50±6.30 cm. All participants had previous football experience of, at least, 5 years, with a training regular basis of 2 h·day-1, 4–5 days^{-1}·week^{-1} (including a weekly competition) during the previous year (except for summertime). No one of the participants had muscle injuries or other discomfort that avoided them to participate. All participants were fully informed about the procedures and possible risks before giving their informed written consent. The study was performed according to the latest version of the Declaration of Helsinki (36) and was approved by the local Hospital Ethics Committee (HUFA 19 52).

Experimental Design and Protocol

A randomized controlled trial with repeated measures was performed. Participants randomly performed 2 sessions under the same experimental conditions (23°C and 50% relative humidity). On one session they performed the FIFA 11+ warm-up protocol (3, 19) using WB-EMS technology (MyoFX EMS System, Madrid, Spain) and on the other session participants performed the same warm-up protocol without using WB-EMS. Sessions were separate by one week and performed during the pre-season period.

The day before each session participants refrained from vigorous exercise. Also, they were instructed to avoid caffeine or alcohol consumption the day of the session and the day before it. Players followed their habitual dietary intake and schedule the day of the experimental sessions. They arrived at their habitual training facility 1 hours before their habitual training time (19:00). Then, players' body weight and height were measured and, right after, they stranded individually, and digital thermal images (thermograms) were recorded for the front and rear surfaces of their bodies. Also, capillary blood lactate was measured. Then, players dressed in a T-shirt, shorts, soccer socks and cleats. Besides, players assigned wore the WB-EMS equipment.

Warm-up FIFA11+ protocol, lasting 25 minutes, was performed by the players leaded by their coach. After warming-up, players immediately ware analyzed for capillary blood lactate and thermal images of their bodies were recorded again. Finally, all the players performed a battery of performance tests to analyze sprinting and jumping ability.

WB-EMS Protocol

The WB-EMS protocol was conducted with a WB-EMS equipment (MyoFX EMS System, Madrid, Spain). WB-EMS was applied with an electrode vest to the upper body including the chest (m. pectoralis major and minor), upper back and lower back (m. latissimus, m. trapezius, m. erector spinae, m. iliolumbales), and abdominals (m. rectus abdominis) and with a belt system to the lower body including the muscles of the glutes (m. gluteus maximus and medius), thighs and hamstrings (m. rectus femoris, m. vastus medialis and lateralis, m. biceps femoris, m. semitendinosus, m. semimembranosus, m. gracilis) and calves (m. gastrocnemius, m. soleus). WB-EMS stimuli was set al follows: current frequency was set at 20Hz, current pulse was set at 350µs, and the wave pulse type was bipolar rectangular. Impulse intensity was individually set to a personal tolerance threshold, ranging from 60 to 100% of the device capacity.

FIFA11+ Warm-Up Protocol

The week before the experiment began, all players were familiarized with the FIFA11+ warm-up protocol. Familiarization and experimental warm-up were conducted by certified ›

Table 1

Thermography and blood lactate data. *=Significantly different than PRE in the same trial; p<0.05. #=Significantly different than WB-EMS at the same time point; p<0.05. WB-EMS=Whole-Body Electromyostimulation.

	WB-EMS		NO WB-EMS		INTERACTION EFFECT			
THERMOGRAPHY (°C)	PRE (1)	POST (2)	PRE (3)	POST (4)	F	p	ηp^2	POST-HOC
Right arm	33.05±0.59	31.31±1.35*	33.24±0.67	32.09±0.98*	20.30	<0.001	0.64	1 vs 2 p<0.001; 3 vs 4 p=0.005
Left arm	33.06±0.63	31.32±1.31*	33.18±0.65	32.06±1.01*	20.81	<0.001	0.65	1 vs 2 p<0.001; 3 vs 4 p=0.004
Right forearm	32.60±0.55	30.64±1.35*	32.88±0.47	31.14±1.16*	20.51	<0.001	0.65	1 vs 2 p<0.001; 3 vs 4 p=0.002
Left forearm	32.64±0.52	30.53±1.49*	32.75±0.47	31.21±1.09*	20.80	<0.001	0.65	1 vs 2 p<0.001; 3 vs 4 p=0.003
Trunk	32.92±0.74	31.03±1.28*	33.19±0.69	31.89±1.15*	22.71	<0.001	0.67	1 vs 2 p<0.001; 3 vs 4 p=0.012
Right thigh	31.74±0.68	30.52±1.51*	31.87±0.65	30.49±1.40*	8.94	0.003	0.44	1 vs 2 p=0.050; 3 vs 4 p=0.010
Left thigh	31.86±0.66	30.67±1.51*	31.98±0.75	30.74±1.36*	8.97	0.004	0.44	1 vs 2 p=0.050; 3 vs 4 p=0.006
Right knee	31.33±0.86	30.42±1.13	31.41±0.73	30.85±0.93	7.79	0.083	0.41	
Left knee	31.26±0.81	30.27±1.14*	31.48±0.77	30.81±0.89*	10.78	0.001	0.49	1 vs 2 p=0.048; 3 vs 4 p=0.042
Right popliteal	31.73±0.61	30.31±1.48*	31.67±0.72	30.21±1.33*	11.28	0.001	0.50	1 vs 2 p=0.020; 3 vs 4 p=0.001
Left popliteal	32.27±0.72	31.02±1.19*	32.39±0.76	31.63±0.96*†	18.14	<0.001	0.62	1 vs 2 p=0.009; 2 vs 4 p=.050; 2 vs 4 p=0.050
Right leg	31.73±0.71	30.71±1.05*	31.83±0.66	31.26±0.71	11.59	<0.001	0.51	1 vs 2 p=0.029
Left leg	31.69±0.70	30.68±1.00*	31.74±0.64	31.17±0.66	10.64	<0.001	0.49	1 vs 2 p=0.047
Lactate ($mmol \cdot L^{-1}$)	1.90±0.96	3.66±1.85	1.46±0.57	5.08±3.29*	9.80	0.002	0.47	3 vs 4 p=0.020

coaches. In this study, we used the level 3 FIFA11+ warm-up protocol, which is the highest level according to difficulty. The mean duration of the protocol in a familiarized player is about 20 to 25 minutes. For more details and information see the manual and instructions freely available on the official website.

Thermography

All the thermograms were recorded with a FLIR T530 imager (FLIR Systems, Stockholm , Sweden) with a sensor array size of 320 × 240 pixels, a thermal sensitivity (NETD)<40 mK, an accuracy of±2%, and a spectral range of 7.5 to 14.0 µm, in a room with a controlled temperature of 23.6±0.8 °C and humidity of 45.0±3.4%. The emissivity of the camera was set to 0.98. The camera was turned on at least 10 min before starting the data collection in order to stabilize the sensors, being placed perpendicular to the subject at a distance of 3 m, avoiding interferences with any source of infrared radiation and using a mate dark background. Data collection was carried out following the guidelines of the TermoINEF protocol (33) and the recommendations of the TISEM consensus document (25).

After following a 15-min acclimatization protocol (11, 30), thermograms of the lower and upper limbs were collected before (PRE) and immediately after experimental trial (POST, i.e. after the warm-up and the performance test) and the software Thermohuman® 2.0 (Thermohuman, Madrid, Spain) was used for obtaining Tsk data from the thermograms. This software automatically delimits regions of interest (ROIs) from the recorded thermograms [i.e., anterior and posterior lower body (18 ROIs), anterior upper body (22 ROIs) and posterior upper body (28 ROIs)] by using automatized artificial vision, providing averaged Tsk of each ROI, its standard deviations, and number of pixels (figure 1). In order to reduce the number of variables and to better analyze the data, the 86 ROIs established by Thermohuman were integrated into 13 consolidated ROIs (i.e. right and left arm, forearm, thigh, leg, anterior knee, popliteal region, and whole trunk) using the averaged values and its corresponding number of pixels (p) in the equation: integrated Tsk=(Tsk1 * p1 + ... + Tskn * pn)/ (p1 + ... + pn). The feet, ankles and neck ROIs were discarded for the analysis to avoid bias originated by the contact on the floor and the influence of hair and face in the thermograms.

Capillary Blood Lactate

Capillary blood lactate levels were measured before and after the warm-up protocol. 5µl of capillary blood from the finger was obtained and then analyzed using a lactate analyzer (Lactate Plus, Nova Biomedical, Switzerland).

Jumping Ability

Countermovement jump (CMJ), squat Jump (SJ), Abalakov jump (ABK), and 15 seconds rebound jump series tests were performed after the warm-up protocol using an infrared laser system (Optojump, Microgate, Italy). For CMJ, SJ and ABK the best jump high (cm) out of three attempts was selected. For the 15-s jump test, participants jumped vertically as high as possible and landed with both feet at the same time, repeating this jumping action for 15-s. Participants were instructed to jump as high as possible simulating header shots. Flight time of all jumps during 15-s were recorded.

Sprinting Ability

After jumping test execution, players performed a 20m sprint test on the field. They stood 0.5 meters behind the starting line and after a countdown of 3 seconds the started sprinting. After a 5 minutes resting time, players performed a repeated sprint ability test (RSA). The RSA included 6 sprint of 20+20 meters (180° change of direction) with 20 s of recovery between sprints (20). Players received verbal motivation during the test and, 6 s before each sprint, they were verbally and visually informed to assume the starting position behind the start line, and from there a countdown of 3 seconds was provided to players. All the sprint times were measured using a set of photocell gates (Smartspeed, Fusion Sport, Australia).

Statistical Analysis

We performed an intention-to-treat analysis. Including all randomized subjects in the analysis procedures. Data from the 15-s jump test, the RSA test, thermography and lactate analysis were analyzed using a two-way ANOVA with repeated measures (trial × repetition for 15-s jump and RSA, and trial × time for thermography and lactate respectively). After a significant F test (Geisser-Greenhouse correction for the assumption of sphericity) differences between means were detected using Bonferroni's multiple comparisons analysis. 20m sprint, CMJ, SJ, ABK and long jump data were examined using two-tailed paired t-test. Also, we calculated the effect size (ES) according to Cohen`d procedures (5) and partial eta squared (ηp^2). The data were analyzed with the SPSS v.24.0 statistical package (IBM, Chicago, IL, USA). The significance level was set at $p \leq 0.05$. The results are presented as means±SD.

Results

All participants completed the experimental trials. Also, none of the participants reported adverse effects during the experimental trials or de following days.

Thermography and Capillary Blood Lactate

Thermography analysis revealed significant differences in Tsk after warm-up with and without WB-EMS (table 1). All the ROIs significantly decreased their Tsk after warm-up except for right knee in both protocols and right and left legs in the NO WB-EMS protocol. Left popliteal Tsk was significantly lower after WB-EMS warm-up protocol compared to NO WB-EMS warm-up ($p<0.05$) with a medium effect size (ES: $\eta p^2=0.62$).

Capillary blood lactate level increased after warm-up in both trials, but this increase reached significance ($p<0.05$) just in the trial without WB-EMS, but with no significant differences between trials (table 1).

Jumping Ability

The use of WB-EMS during the warm-up did not significantly change players' performance in CMJ, SJ, ABK or Long jump test compare to the regular warm-up (table 2). Also, during the 15s jump test, all players reached seventeen jumps, and again, no significant differences were seen between warm-up protocols along the jumps (F=1.26, p=.15, ES: $\eta p^2=0.10$; figure 2). On average, players jump height after WB-EMS warm-up was 32.4±7.0 cm and after NO WB-EMS warm-up 32.7±4.3 cm (ES: d=0.06; figure 2).

Sprinting Ability

Players showed a significantly higher sprinting performance (i.e. 0.2 seconds faster) in the 20m sprint test after warm-up with WB-EMS compared to regular warm-up ($p<0.05$; table 2). Regarding the RSA test however, although two-way ANOVA shown a significant main effect for repetitions (F=87.64, p=0.026, ES: $\eta p^2=1.00$) and interaction between repetitions and warm-up protocol (F=42.00, $p<0.001$, ES: $\eta p^2=0.79$), post hoc analysis only shown a significant increase of the time to complete the 20+20 meters when comparing sprint 1 to sprint 2 in both warm-up protocols (p=0.004 and p=0.011 for WB-EMS and regular warm-up respectively), with no differences between using or not WB-EMS (figure 3). Besides, the RSA average time to complete the sprint distance was 8.70±0.32 seconds and after WB-EMS warm-up and 8.71±0.35 seconds after regular warm-up (ES: d=0.02; figure 3).

Figure 2

Results of the 15 seconds jump test performance. Data shows the mean and SD results of all players in each jump and the average of all jumps. Black=WB-EMS; White=No WB-EMS.

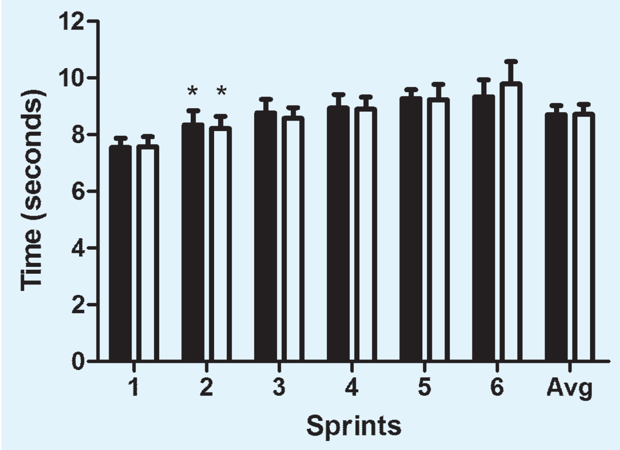

Figure 3

Results of the repeated sprint ability test performance. Data shows the mean and SD results of all players in each sprint and the average of all sprints. Black=WB-EMS; White=No WB-EMS.

Discussion

The main findings of this study were the identification of the differences between applying a warm-up protocol with and without WB-EMS and its effect on football players performance abilities. Our results showed a significant difference after the application of both protocols in left popliteal Tsk when applying WB-EMS (Δ=0.61 °C) but no differences were found in the rest of body regions. We did not find significant differences in blood lactate nor in jumping ability between both protocols. Regarding sprinting ability, although our data did not show significant differences in the RSA test, we found a significant difference in the time to perform a 20m sprint. Our hypothesis was based on the idea that a brief use of WB-EMS during ›

Table 2

Performance data. *=Significantly different from NO WB-EMS; p<0.05. WB-EMS=Whole-Body Electromyostimulation.

VARIABLES	WB-EMS	NO WB-EMS	T	COHEN'S D	% CHANGE
20m sprint (seconds)	3.38±0.15*	3.58±0.26	0.03	0.94	5.94
CMJ (centimeters)	34.48±2.94	34.47±3.64	1.00	0.01	0.01
SJ (centimeters)	34.98±4.76	32.91±4.16	0.18	0.46	5.93
ABK (centimeters)	41.32±3.01	40.88±6.35	0.70	0.08	1.08
Long jump (centimeters)	2.19±0.30	2.14±0.17	0.38	0.20	2.66

the warm-up could improve the football players performance due to its ability to improve neuromuscular signal. Nevertheless, although we showed an improvement in 20m sprint and an increase in left popliteal Tsk, we did not find significant differences in the rest of performance tests.

WB-EMS warm-up protocol would improve sport performance because of it increases blood flow and, as a consequence, body temperature (34). It is known that exercising elicits and increase in internal temperature that must be controlled in order to not damage body systems (14). There is a constant cross-talk between skin and musculoskeletal system that allows to regulate the sweat and the temperature of the blood (Mechanisms and modifiers of reflex induced cutaneous vasodilation and vasoconstriction in humans). As a result, scientific evidence suggests that the Tsk is reduced after exercising (9, 10, 34).

This phenomenon is mainly explained by convection that allows to remain the body temperature at a constant and safe level (12). We found this decrease in skin temperature after the both warm-ups in all body regions except for the right knee that did not present significant differences. On the other hand, our data showed that the protocol with WB-EMS remain the left popliteal Tsk lower than the protocol without WB-EMS. This result should be explained by anatomical differences between legs (i.e., presence of veins or arteries) (26). We could assume that the decrease in Tsk may lead to an increase in muscular temperature. We assume that if the muscles maintain higher temperatures during the warm-up, it results in better sport performance (34), because it seemed that when exercising with WB-EMS, blood flow to the muscles is increased, thereby enhancing the supply of oxygen to the muscles, making the effort more efficient.

Regarding lactate levels our results showed that performing the warm-up without WB-EMS increase the blood lactate levels (Δ=3.62 mmol·L-1) while WB-EMS protocol did not (Δ=1.76 mmol·L-1). These results are in agreement with the study of Bizzini et al. (3) that found significant differences in blood lactate after applying FIFA 11+ warm up (Δ=1.6 mmol·L-1) . Nevertheless, these results contrast with the idea that WB-EMS increases the intensity of the exercise although previous studies have already confirmed it (27). In addition, Hultman & Spriet (18) showed a peak in blood lactate levels when applying EMS (Δ=66.5 mmol·kg-1).. However, this result may be explained by a lower Tsk that leads to a lower energetic efficiency. There is not enough scientific data to confirm our results and the positive impact of the WB-EMS in lactate metabolism.

The effects of both warm-ups appear to not improve the jump performance. No differences in jump ability were obtained in the CMJ, SJ, ABK or long jump after both warm-ups. These results are opposed to the research performed by Bizzini et al who performed the FIFA 11+ warm-up and saw a better performance in CMJ after it (3). However, while they measured the CMJ before and after the FIFA 11+ warm-up, we compared two sorts of warm-ups. Moreover, the jump performance between participants were quite different since the mean height achieved by our participants was 34.47 cm while Bizzini et al found a mean height of 44.90 cm. This difference might be due to the age of the participants (21.75±1.86 vs. 25.5±5.1 years old) because the football level (amateur) and the anthropometric values remain similar between studies. Similarly, Vetter, R. showed higher jump ability with dynamic exercises compared to static exercises (35). They stated that warm-ups involving static stretching are counterproductive to performance. Similar to our results they also measured the jump ability after the warm-up and did not take baseline measurements. By contrast, others authors such as Zois et al (38)found an improvement in jump ability after performing 5-repetition maximum in a leg press machine and two intermittent-activity protocols consisting of sprinting, slalom, walking and other exercises. Although we did not find differences in CMJ with WB-EMS nor without WB-EMS it is known that the effects of WB-EMS on post-activation potentiation are limited. Dote Montero et al (7) showed that WB-EMS protocol did not produce a significant increase in maximum isometric strength compared to the control conditions. In this sense, Gourgouliss V. et al (16) performed similar research evaluating the CMJ before and after a warm-up protocol consisting of 5 sets of 2 repetitions of half-squats at 20, 40, 60, 80 and 90% of the repetition maximum. This protocol was also related to better results in jump performance (Δ=0.81 cm) although being different from the FIFA 11+ protocol. It must be said that in they only performed jump tests while we measured jump ability, sprint velocity and RSA.

Concerning sprint performance, we measured the speed ability with the RSA test and the 20 m sprint test. We found a significant difference only in 20 m sprint with no differences between protocols in the RSA capacity. Our data suggests that performing the FIFA-11+ warm-up with WB-EMS improves the capacity to run 20m in less time (Δ=0.2 seconds). The improvement in the 20m sprint test is crucial since sports such as football are continuously performing short and long distances sprints. In this line we found the article by Alikhajeh Y. et al (2) that compared different warm-up protocols in the 20m sprint performance. They found an improvement in 20m sprint after dynamic stretching (Δ=0.06 seconds). On the other hand, Byrne, P. et al (4) also compared static and dynamic stretching adding 3 depth jumps to the warm-up. Curiously, they found that the protocols with dynamic stretching and depth jumps decrease the time of 20 m sprint test compared to the static stretching (Δ=0.17 seconds). The main point is that performing warm-ups that enhance neuromuscular capacity combining dynamic stretching, aerobic and strength exercises are related to better performance in 20m test. In this sense, the FIFA 11+ warm-up has a similar planning and our study shows a positive effect of WB-EMS in 20m sprint test. This discovery is especially interesting for football players that needs to make short and explosive sprints during the whole match. However, the RSA remains similar with and without WB-EMS warm-up protocols. So that, future studies should focus on carrying out a protocol that improves this variable due to its implication in football performance.

The results of this study should be considered with caution as there are some limitations. First, we did not manage a control group. Thus, we cannot compare the effect of performing this sort of warm-up instead of not doing it. Secondly, we evaluated our participants during the pre-season time. It is commonly known that during this period the physical condition of the athletes is quite poor, and the trainings are physically demanding. Therefore, the results of our study could be underestimated. Thirdly, we did not measure the jumping and speed ability before the warm-up and thus, we don't know if they increase or decrease their performance. Regarding the variables analyzed through a paired t-test, it is important to point out that this procedure is more sensitive, and thus, the results may be underestimated. To finish, the elapsed time between the end of the warm-up and the performance test is highly important in this kind of studies. Depending on this time the result might be different. And, the order of the test could have an impact on the results.

In addition, it is important to note that, despite the author's decision to apply a specific and standardized football warm-up well-known by the participants, the effects of WB-EMS could be more significant in a state-of-the-art warm-up protocol. Future research should consider new warm-up methods as described by McCogan et al. (25).

Conclusions

In conclusion, our findings support the idea that WB-EMS warm-up has the potential effect of increasing regional body temperature and to has a positive impact in 20 meters test. Previous studies have shown to improve muscular performance after applying complicated protocols. However, we applied a comfortable and useful technology that enhances muscular performance. Future studies are needed to clarify the effect of WB-EMS during the warm-up before the competition, with methodologically better design, including different warm-up protocols, and applying the same protocol in women to test the efficacy on both sexes.

Conflict of Interest

The authors have no conflict of interest.

Summary Box

The aim of this study was to analyze if adding WB-EMS to the warm-up increases or not football players performance. Thermography showed that skin temperature (Tsk) significantly decreased after both protocols, and only left popliteal Tsk was significantly lower after WB-EMS warm-up protocol compared to NO WB-EMS warm-up ($p < 0.05$). Lactate was higher after NO WB-EMS but not after WB-EMS warm-up. Sprint performance in 20 meters was significantly faster after WB-EMS compared to NO WB-EMS.

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