Effects of Electrostimulation Therapy on Recovery From Acute Team-Sport Activity

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Purpose: To assess the efficacy of a 1-off electrostimulation treatment as a recovery modality from acute team-sport exercise, directly comparing the benefits to contrast water therapy. Methods: Ten moderately trained male athletes completed a simulated team-game circuit (STGC). At the conclusion of exercise, participants then completed a 30-min recovery modality of either electrostimulation therapy (EST), contrast water therapy (CWT), or a passive resting control condition (CON). Twenty-four hours later, participants were required to complete a modified STGC as a measure of next-day performance. Venous blood samples were collected preexercise and 3 and 24 h postexercise. Blood samples were analyzed for circulating levels of interleukin-6 (IL-6) and C-reactive protein (CRP). Results: The EST trial resulted in significantly faster sprint times during the 24-h postrecovery than with CON ($P < .05$), with no significant differences recorded between EST and CWT or between CWT and CON ($P > .05$). There were no differences in IL-6 or CRP across all trials. Finally, the perception of recovery was significantly greater in the EST trial than in the CWT and CON ($P < .05$). Conclusions: These results suggest that a 1-off treatment with EST may be beneficial to perceptual recovery, which may enhance next-day performance.

Keywords: muscle soreness, muscle damage, perceptual response
response, the perception of recovery, and next-day athletic performance. Furthermore, the outcomes were compared with those resulting from the more commonly practiced recovery process of CWT and with a passive control condition of seated rest (CON).

**Methods**

**Participants**

Ten moderately trained men were recruited from local amateur soccer and Australian Rules Football clubs for this study (age 20 ± 3 y, height 180.1 ± 10.1 cm, body mass 81.4 ± 10.3 kg). Participants were informed of the requirements and risks associated with their involvement before written consent was obtained. Ethical approval for the use of human subjects during this investigation was granted by the University of Western Australia’s Human Research Ethics Committee (RA/4/1/4025).

**Experimental Procedures**

During this investigation, participants were asked to attend 4 laboratory-based testing sessions over a 4-week period. The initial session was used as a familiarization trial, requiring each participant to undergo the exercise protocol and to briefly sample each recovery protocol. Each subsequent trial was conducted over a 2-day period, with the exercise protocol completed on an outdoor grassed oval. On day 1 of each trial, participants arrived at the laboratory at 9 AM, and an initial preexercise venous blood sample was collected before a standardized 10-minute warm-up commenced. The warm-up included 6 laps of the simulated team-game circuit (STGC) that was used in the ensuing exercise trial. After the warm-up, a 10-minute rest period was allowed, after which the participants commenced the STGC, comprising six 15-minute work bouts separated by 5-minute recovery periods.

The STGC was developed to replicate the typical intermittent demands and movement patterns commonly observed during team-sport activity. Each 15-minute block of the STGC involved the completion of 15 × 1-minute circuits. Each 1-minute circuit commenced with a maximal 20-m sprint, which was used as the exercise-trial performance indicator. At halftime and the final 5-minute rest periods of the STGC, participants were required to ingest 100 mL of water, and recordings of their average heart rate (HR) and a rating of perceived exertion (RPE) were collected. At the conclusion of the STGC, participants were required to undergo 1 of 3 different recovery modalities, which were implemented in a repeated-measures, counterbalanced order. The 3 recovery modalities were EST, CWT, and CON.

**EST.** For EST, a one-off 30-minute EST using a portable Bodyflow® device was implemented whereby 4 thermal cups were attached to the adductor muscle group and the medial head of the gastrocnemius muscle of each leg. A mild transdermal stimulus of 1 to 2 Hz was applied to this area through each thermal cup, at a device setting of 11 mA. The manufacturer of this machine suggests a variable device setting to induce a slight muscle twitch through a range of 0 to 40 mA. However, a fixed intensity of 11 mA was found to induce such a twitch response during our preinvestigation pilot testing and was, as such, used to avoid the confounds of a variable stimulus intensity.

**CWT.** For CWT, participants were immersed to their waist line while standing up in water baths, alternating 2-minute immersions of cold (12°C ± 1°C) and warm water (30°C ± 1°C), repeated 6 times (with a 30-s transfer time between baths) for a total time period of 30 minutes. Only the lower body was immersed during this intervention to replicate the EST stimulus applied to the legs only.

**CON.** For CON, participants remained seated in a rested state for 30 minutes postexercise in the exercise physiology laboratory. On completion of the 30-minute recovery intervention, participants were asked to remain at the laboratory for a 3-hour period of seated rest. At the conclusion of this 3 hours, a venous blood sample was collected from the forearm, before the participants were permitted to leave the testing facility, with the instruction to not partake in any further modes of recovery, including any physical activity, stretching, water immersions, or wearing of compression garments. To monitor their nutrition over this period, participants were provided with a food diary and instructed to record the intake of all foods and fluids for the 24 hours after each experimental trial. This information was then provided to the athlete after each subsequent experimental trial, and they were asked to follow their same eating habits on each occasion.

Twenty-four hours postintervention the athletes were required to return to the laboratory to complete a follow-up testing protocol. On their return, participants provided a venous blood sample from the forearm before completing the aforementioned 10-minute warm-up, followed by an exercise-performance trial consisting of three 15-minute blocks of the STGC. During this follow-up assessment, the initial 20-m sprint of each 1-minute repetition was used as the performance indicator.

**Environmental Conditions**

Before the commencement of each experimental trial, the environmental temperature and relative humidity were recorded using a digital temperature and humidity monitor (Fluke 971, Taiwan). The average environmental conditions during the STGC were 17.7°C ± 3.0°C, 36.0% ± 5.0%, and during the next-day performance trial were 19.7°C ± 2.3°C, 35.3% ± 6.3%.

**Blood-Sample Collection, Preparation, and Analysis**

Venous blood was collected via venipuncture of an antecubital vein in the forearm with the participant lying down for 10 minutes to control for postural shifts in plasma volume. Samples were collected using a 21-gauge needle...
and an 8.5-mL SST II gel collection tube (BD Vacutainer). Each sample was allowed to clot for 60 minutes at room temperature before being centrifuged at 10°C and 3000 rpm for 10 minutes. The serum supernatant was divided into 1-mL aliquots and stored at –80°C until batch analysis was conducted at the Royal Perth Hospital pathology laboratory.

High-sensitivity interleukin-6 (IL-6) was measured as a marker of inflammation from venous blood samples taken preexercise and at 3 hours postexercise, using the Quantikine hsIL-6 ELISA method by R&D Systems (R&D Systems Europe Ltd, Abingdon, UK). The coefficient of variation (CV) was 7.70% at 5.45 pg/L and 5.85% at 1.20 pg/L. High-sensitivity C-reactive protein (CRP) was measured from venous blood samples taken preexercise and 24 hours postexercise using a particle-enhanced immunonephelometric method on the BNII analyzer (Dade Behring GmBH, Marburg, Germany). The CV was 8.35% at 0.63 mg/L and 7.69% at 4.55 mg/L.

HR and RPE

Participants’ HR and RPE were recorded at baseline, at halftime, and at the conclusion of the STGC via an HR monitor (Polar 625X, Finland) and the Borg perceptual scale.10 This scale encompassed the anchor points 6 (no exertion at all) to 20 (maximal exertion).

Perceptual Recovery Questionnaire

At the conclusion of each recovery intervention, participants were asked to rate their perceived recovery using the Total Quality Recovery Perceived scale11 encompassing the anchor points 6 (very, very poor recovery) to 20 (very, very good recovery).

Total Sprint Time

The individual 20-m-sprint time recorded during each 1-minute circuit of the STGC was recorded using electronic timing gates (SmartSpeed, Fusion Sport, QLD, Australia). The sum of the 15 individual 20-m-sprint times from each set of the STGC (ie, from all 15 repetitions) is presented and analyzed as the performance indicator of this investigation.

Statistical Analyses

The data are presented as mean and SD. However, standard error (±SEM) has been used in the figures for clarity. A repeated-measures ANOVA was used to calculate the interactions between the recovery condition and the subsequent blood, perceptual, and performance parameters gathered. Pairwise least-significant-difference comparisons were made post hoc where applicable to clarify a main effect. The alpha level was set at \( P \leq .05 \). A Shapiro-Wilk calculation was assessed for data normality. Where appropriate, Cohen \( d \) effect sizes were calculated to suggest data trends and were interpreted as \( d \leq .3 \), small; \( d = .31 \) to .69, moderate; and \( d \geq .7 \), large.

Results

STGC

There were no differences in the sum of the 20-m-sprint times for each set between the EST, CWT, and CON conditions during the STGC (\( P > .05 \)). There was a significant time effect (\( P < .05 \)) apparent for the sprint times recorded within each condition. Specifically, as the STGC progressed the time to complete each set became significantly slower (Table 1). In addition, there were no significant time or trial effects for the HR (\( P > .05 \)) or RPE (\( P > .05 \)) collected between all 3 experimental conditions (Table 1).

24-Hour-Postrecovery Performance Trial

The sums of the 20-m-sprint times recorded during the 24-hour-postrecovery performance trial are presented in Table 1. There was a significant trial effect for the difference in sprint times recorded between the 3 recovery conditions (\( P < .05 \)). Specifically, there was a significant difference apparent between EST and CON (\( P = .004 \)), showing faster sprint times in the EST. However, there were no significant differences between the CWT and EST (\( P = .58 \)), nor between the CWT and CON (\( P = .19 \)). Despite this, there was a moderate effect to suggest a trend toward achieving faster sprint times in the 24-hour-postrecovery performance trial after CWT compared with the CON (\( d = .35 \)). There were no significant trial effects for HR (\( P > .05 \)) or RPE (\( P > .05 \)) between the experimental conditions (Table 1).

Total Quality Recovery

The participants’ ratings of perceptual recovery (Figure 1) before the 24-hour-postrecovery performance trial showed significant differences between trials, with the perceptual recovery of EST being significantly greater than CWT or CON (\( P < .05 \)). In addition, the CWT also had a significantly greater effect on the athletes’ perception of recovery than the CON (\( P < .05 \)).

IL-6

There were no significant trial (\( P = .349 \)) or trial × time (\( P = .176 \)) effects found between the 3 recovery conditions for circulating levels of IL-6. However, there was a significant time effect (\( P < .05 \)) within each recovery condition (Figure 2[A]), which showed the 3-hour postexercise IL-6 levels to be significantly increased. In addition, the relative change in IL-6 levels from baseline showed no significant differences between the 3 conditions (EST = 1.68 ± 1.34 pg/mL, CWT = 0.91 ± 0.94 pg/mL, CON = 1.46 ± 0.77 pg/mL; \( P = .176 \)).

CRP

There were no significant trial (\( P = .949 \)) or trial × time (\( P = .703 \)) effects recorded for the CRP levels between the 3 experimental trials (Figure 2[B]). In addition, there
Table 1  Sums of the 20-m-Sprint Times, Heart Rate, and Ratings of Perceived Exertion (RPE) During the 90-min Simulated Team-Game Circuit (STGC) and the 24-h-Postrecovery Performance Trial, Mean (SD)

<table>
<thead>
<tr>
<th>Trial</th>
<th>90-min STGC (6 × 15-min sets)</th>
<th>24-h-Postrecovery Performance Trial (3 × 15-min STGC sets)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Set 1 ∑20-m time (s)</td>
<td>Set 2 ∑20-m time (s)</td>
</tr>
<tr>
<td>EST</td>
<td>60.03 (7.17)</td>
<td>62.27 (6.22)</td>
</tr>
<tr>
<td>CWT</td>
<td>58.45 (6.62)</td>
<td>60.12 (7.18)†</td>
</tr>
<tr>
<td>CON</td>
<td>58.44 (6.77)</td>
<td>61.29 (7.19)†</td>
</tr>
</tbody>
</table>

*Significantly different from CON (P < .05). †Significantly different from set 1 (P < .05). ‡Significantly different from previous set (P < .05).

Figure 1 — Mean (± SEM) ratings on the Total Quality Recovery Perceived Scale encompassing the anchor points 6 (very, very poor recovery) to 20 (very, very good recovery) for the electrostimulation therapy (EST), contrast water therapy (CWT), and control (CON) trials. *Significantly different from CWT (P < .05). †Significantly different from CON (P < .05).

were no significant differences in the relative change from baseline between trials (EST = 1.52 ± 1.35mg/L, CWT = 1.18 ± 0.61 mg/L, CON = 1.42 ± 1.36 mg/L; P = .467). There was, however, a significant time effect within each recovery condition that showed the 24-hour-postexercise CRP levels to be significantly greater than those recorded preexercise (EST P = .006, CWT P < .05, CON P = .009).
Figure 2 — Mean (± SEM) circulating levels of (A) interleukin-6 collected preexercise and 3 h postrecovery and (B) C-reactive protein collected preexercise and 24-h postrecovery for the electrostimulation therapy (EST), contrast water therapy (CWT), and control (CON) trials. *Significantly different from preexercise (P < .05).

Discussion

The current study investigated the efficacy of a single treatment with EST as a recovery modality from acute team-sport exercise and directly compared any benefits with those of the more commonly practiced CWT and those of resting control over the same duration of exposure. The results showed that the EST was a superior recovery intervention compared with CON, resulting in significantly faster sprint times during the next-day performance trial, as well as generating a greater perception of postexercise recovery. In addition, the outcomes of this investigation demonstrated that CWT was also effective in enhancing athletes’ perception of recovery compared with the CON trial.

In the current investigation, participants were able to complete the 20-m sprint bouts during the 24-hour-postrecovery performance trial significantly faster after...
having received the EST, with a trend toward better performances after having received the CWT compared with the CON trial. When considering the previous research that has suggested that different forms of EST are responsible for a decreased inflammatory response7 or for an increase in circulation and lymphatic flow8 and that varying water temperatures during CWT may induce a circulatory-pump effect to enhance blood flow and metabolic byproduct accumulation,4 it might be assumed that such mechanisms may have allowed athletes to return to a more homeostatic state in a reduced amount of time, thereby improving subsequent athletic performance. However, within the scope of the blood measures collected here, our data show no attenuation or reduction in the inflammatory or muscle-damage markers during the postexercise period. Despite this lack of response in the measures that were assessed here, a number of potential mechanisms that may have improved our athletes’ recovery (such as a reduction in edema, reduced subjective pain responses, or an increased range of motion) were not measured, and, as such, it may be that these markers of recovery could provide further insight into the beneficial physiological effects of EST and CWT on enhancing subsequent athletic performance.

The lack of impact of the CWT on the postexercise inflammatory response seen here is consistent with other previous research, where protocols inclusive of ~60 seconds in cold water (8–12°C), followed immediately by an immersion for 60 to 120 seconds in warm water (38–42°C) for a total duration of ~15 min have been used.3–5,12 Such outcomes might be explained by the fact that the participants here were only immersed to their waist, resulting in only half of the body exposed to any increases in hydrostatic pressure. It has previously been suggested that by increasing the depth of immersion, a greater physiological response may be seen as a result of an increased hydrostatic pressure.1 However, since the EST was only attached to the lower limbs of the participants in this study, a comparison of CWT applied to the same area was more appropriate for between-trials comparisons. With respect to the EST trial, the lack of influence on the postexercise inflammatory response is contrary to the suggestions of electrostimulation’s resulting in increased circulation and reduced inflammatory response.7 Despite the differences in outcomes, the ineffectiveness of the EST used here to influence the IL-6 and CRP responses may be in part due to the lower-intensity stimulus provided (ie, 1–2 Hz at 11 mA vs 5 Hz) or to the one-off nature of the stimulus provided, as opposed to the previously established initial 20-minute treatment, followed by a further 7 days of intermittent use.8 To this end, the beneficial physiological mechanisms of recovery that EST may provide still require further investigation.

From the variables measured throughout this investigation, it is possible to conclude that an enhanced perception of recovery may be the most plausible mechanism to help explain the enhanced sprint performances seen in the 24-hour-postrecovery trial for the EST condition and for the trend in performance enhancement in the CWT trial. Such an enhanced perceptual response may increase an athlete’s state of well-being, translating to an enhanced next-day athletic performance, compared with the postexercise feelings of poor recovery in the event of no recovery protocol being implemented at all. Previous research has suggested that CWT may improve the perception of recovery by decreasing muscle soreness in the 24-hour-postexercise period, compared with control trials of no recovery modality being implemented.3–5 It is likely that such improvements in the perception of recovery during both the EST and the CWT trials are linked to the potential of an increased rate of acute exercise recovery via physiological changes such as the proposed fluid shifts and circulatory changes that are suggested to be invoked by the applied stimulus. With this in mind, it is possible that an improvement in these physiological processes may lead to enhancement of an athlete’s perception of well-being (and therefore recovery) at the conclusion of a structured recovery intervention and before the subsequent exercise session on the following day.

Practical Applications

The results of this investigation suggest that structured postexercise recovery sessions that use acute EST or CWT may result in enhanced next-day athletic performance. As a result, 30 minutes of EST using a portable Bodyflow unit or 30 minutes of CWT alternating 2-minute immersions of cold- (12°C ± 1°C) and warm-water (30°C ± 1°C) exposures should be considered when next-day athletic performance is of concern.

Conclusion

In the current study, significantly faster sprint times were evident in the 24-hour-postrecovery performance trial after the use of an acute EST stimulus. Furthermore, there were moderate trends for a similar improved performance after CWT. These outcomes may be a result of the participants’ enhanced perception of recovery after the implementation of a structured recovery session, likely increasing the athletes’ state of well-being, thus translating to enhanced next-day athletic performance. It was, however, evident that the EST and CWT protocols had a limited impact on the inflammatory response and muscle damage. The lack of responsiveness in these markers to the treatment protocols may be a result of the immersion level in the CWT trial or due to the duration, frequency, and amplitude of the EST. However, since we did not measure blood-flow changes, it is difficult to ascertain whether the EST intensity in the current study was sufficient to influence circulation, and therefore further research is warranted into the mechanism of action brought about by such recovery modalities.
References


