Effect of Water Immersion on Post-Exercise Recovery from a Single Bout of Aerobic Exercise

Renata Silva¹, Lorena Cleto¹, Nathália do Valle¹, Fernando Gripp², Etel Rocha-Vieira², Kelerson Pinto³

¹Department of Basic, Biological and Environmental Sciences, Centro Universitário de Belo Horizonte, Belo Horizonte, ²School of Biological and Health Sciences, Federal University of Jequitinhonha and Mucuri Valleys, Diamantina ³CEDUFOP, Federal University of Ouro Preto, Ouro Preto, Brazil

ABSTRACT

Silva R, Cleto L, do Valle N, Gripp F, Rocha-Vieira E, Pinto K. Effect of Water Immersion on Post-Exercise Recovery from a Single Bout of Aerobic Exercise. JEPonline 2011;14(6):47-53. This study evaluated the effect of water immersion on physiological parameters at post-exercise recovery. Four male volunteers (26 ± 3.93 yr; VO₂ peak 52.12 ± 9.07 mL·kg·min⁻¹) underwent a unilateral eccentric knee extension followed by 30 min of treadmill exercise at 70% of VO₂ peak. Immediately after, they were subjected to three different protocols of water immersion, for 15 min: cold-water immersion (CWI), hot-water immersion (HWI), and intermediate-water immersion (IWI). Control group remained seated on bath tube with no water for 15 min. Protocols were conducted in a cross-over balanced way with 7 days of interval between tests. Heart rate (HR), body temperature, and serum lactate levels were monitored during exercise and recovery and excess post-exercise oxygen consumption (EPOC) measured during recovery. Body temperature was reduced during CWI and HR was increased during both CWI and HWI. However, no effect of water immersion was observed on lactate levels and EPOC. The findings indicate that water immersion affects the recovery of some physiological parameters following exercise, but not all. How this modified physiological response influences exercise performance is under investigation.

Key Words: Heart rate, EPOC, Skin temperature, Lactate
INTRODUCTION

Getting the right balance between training, competition, and recovery is essential to maximize the performance of athletes. After the exercise heart rate (HR), oxygen consumption (VO₂), body temperature, and the number of circulating leukocytes can take up to 48 hr to return to the levels of homeostasis, depending on the parameter considered and the duration and intensity of exercise (8). Although recovery protocols are actually used as part of training programs of athletes to ensure a balance between training, competition, and recovery, little is known about the efficiency of such protocols.

It has been suggested that water immersion may improve recovery after exercise (2). Lane and Wanger (6) and Vaile et al. (11) demonstrated improved performance in cycle ergometer test, after recovery from a previous exercise by immersion at cold water (15°C to 10°C). Bailey et al. (1) demonstrated a reduction in the onset of delayed muscle soreness (DOMS) using immersion at 10°C for 10 min after prolonged intermittent exercise, accompanied by a reduction in plasma levels of myoglobin. However, Crowe et al. (3) investigated the effect of cold water immersion (13/14°C for 15 min) during recovery of anaerobic exercise on a cycle ergometer and found that the peak strength, total work, and serum lactate levels after exercise were lower in cold condition. Also, Sellwood et al. (9) reported that three immersions of 1-min each in water at 5°C was not effective in minimizing DOMS and serum levels of creatine kinase.

Vaile et al. (11) showed that although hot water immersion was effective in recovering strength in isometric leg press protocol, it was ineffective in the recovery of other parameters related to DOMS, such as pain perception and muscle swelling. Kubo et al. (5) reported that immersion in hot water does not improve mechanical properties (such as elongation and force generation in muscles and tendons). The research findings regarding the effects of water immersion on recovery of exercise are conflicting. The effectiveness of water immersion as a recovery method may rely on the physiological effects of water immersion and the modulation of physiological parameters related to exercise recovery. In this context the present study evaluated the effects of water immersion at different water temperatures on body temperature, HR, blood lactate and EPOC during the recovery of a single bout of aerobic exercise.

METHODS

Subjects
Four healthy subjects (young men) were recruited for the present study, which was approved by the Committee on Human Experimentation of the Centro Universitário de Belo Horizonte (protocol 009/2008). The subjects were non-smokers with a VO₂ capacity greater than 35 mL•kg•min⁻¹. They presented no restriction for physical activity, and they were not taking medication during the study.

Procedures
One Maximum Repetition and Maximum Aerobic Capacity
To establish individual maximum repetition, the subjects were submitted to the one maximal repetition (MR) test using a procedure prescribed by the National Strength and Conditioning Association (6). After 30 min of rest, the subjects then exercised to maximum to establish individual maximum aerobic capacity (VO₂ max). During the test, which followed the Ellestad protocol, VO₂ was measured by indirect calorimetry using the gas analyzer VO2000 (Inbrasport®, Rio Grande do Sul, Brazil).
**Exercise Protocol**

The subjects performed an eccentric knee extension at 120% of 1MR unilaterally that consisted of 1 series of 10 repetitions. The subjects then ran on a treadmill at 70% of VO₂ max for 30 min, which was followed immediately by a passive recovery for 15 min immersed in water up to the height of the xiphoid process at 38°C (hot water immersion - HWI), 18°C (cold water immersion - CWI), or 28°C (intermediate water immersion - IWI). During the control period, the subjects remained seated on the bathtub for 15 min with no water. Environmental temperature on the test days was maintained between 20 and 24°C.

**Measurements**

During exercise and recovery protocols, HR was monitored through a cardiofrequencimeter (Polar®, USA) at 20 sec intervals. Oxygen consumption and ventilation measurements were made by indirect calorimeter using open-circuit respirometry (VO2000, Inbrasport®, Rio Grande do Sul, Brazil). Blood lactate levels were measured using lactate strips (Accutrend BM® lactate test strips) and a portable lactate analyzer (Accutrend® lactate portable lactate analyzer). Blood samples were obtained by a small incision on finger before and after exercise and following recovery protocol. Mean skin temperature (Ts) was calculated according to the following formula (11): Mean (Ts) = 0.6 Ts trunk + 0.1 Ts arm + 0.2 Ts tigh + 0.1 Ts forehead

**Statistical Analyses**

The data are reported as mean ± SD. The effect of the recovery protocols on HR, EPOC, blood lactate, and body temperature was accessed through analysis of variance adjusted to the Latin square with statistical significance set at P = 0.05.

**RESULTS**

Table 1 presents the physical characteristics of subjects. The effect of exercise and recovery by water immersion in blood lactate levels are shown in Figure 1. Lactate levels were increased (P = 0.01) immediately after exercise compared to pre-exercise levels, and were reduced after the recovery period (P = 0.01). However, no effect of water immersion, independent of the water temperature, was observed on the lactate levels following recovery. As shown in Figure 2 no effect of the recovery protocols was observed on the EPOC (P = 0.149). Mean skin temperature was not affected by the exercise. However, it was significantly reduced after CWI (P = 0.05), compared to the other situations and to the post-exercise condition (Figure 3). Heart rate was not different between the four recovery conditions until the 6th min of the recovery period (Figure 4). However, HR was significantly increased (P = 0.05) in the volunteers submitted to HWI at the 9th and 15th min of recovery. After 12 and 15 min of recovery, HR was higher in the CWI compared to the control and IWI condition.

**DISCUSSION**

Although water immersion has been proposed and employed as a strategy to improve exercise recovery, there is still controversy as to its efficacy. In the present study, it was demonstrated that water immersion for 15 min, independent of water temperature, does not improve post-exercise lactate levels and EPOC, although it influenced skin temperature and HR in a manner dependent of the water temperature.
Similar to the present study, Vaile et al (11) reported a 30% reduction in blood lactate levels after exercise recovery but with no effect of water immersion or water temperature. However, Morton (7) and Hamlin (4) reported reduced lactate levels following contrast water therapy during the recovery of an exercise. Similar data were obtained by Crowe et al. (3) when they used cold water immersion during aerobic exercise recovery. These divergences may be attributed to the exercise employed and the duration of recovery time, especially since the authors used high intensity anaerobic exercise and longer recovery periods.

![Figure 1. Water immersion after exercise does not improve the recovery of blood lactate. CWI = cold water immersion (18°C), IWI = intermediated water immersion (28°C), HWI = hot water immersion (38°C), CN = control (no water immersion). There was no statistically significant difference between treatments. * P = 0.05 when compared to pre-exercise condition. **P = 0.05, compared to post-exercise condition.](image1)

Post-exercise water immersion did not influence EPOC, thus indicating that neither a metabolic nor thermoregulatory stress was imposed during the post-exercise recovery by water immersion. As expected, mean skin temperature was reduced following cold water immersion. Similar results have been reported by Vaile et al. (11). They observed a decrease in body temperature following immersion in water at a 10°C, 15°C and 20°C compared to passive recovery. Also, Bailey and colleagues (1) reported a reduction in body temperature from 37.9°C to 37.7°C during cold water immersion after exercise.

![Figure 2. Water immersion after exercise does not affect the EPOC. CWI = cold water immersion (18°C), IWI = intermediated water immersion (28°C), HWI = hot water immersion (38°C), CN = control (no water immersion). There were no statistically significant differences among treatments.](image2)
Figure 3. Mean skin temperature is reduced following cold water immersion after exercise. CWI = cold water immersion (18°C), IWI = intermediated water immersion (28°C), HWI = hot water immersion (38°C), CN = control (no water immersion). *P = 0.0240 compared to the other treatments. #P = 0.0025 compared to the post exercise condition.

Heart rate was higher during hot water immersion at the 9th and 15th min of recovery, and also during cold water immersion, which reflects a higher cardiovascular stress due to the temperature of water. Also, the subjects’ HR response was higher at the 12th and 15th min of recovery in cold water, different from the data reported by Vaile and colleagues (10), that have compared the effect of cold water immersion to active recovery.

Figure 4. Heart rate after exercise is modulated by cold and hot water immersion. CWI = cold water immersion (18°C), IWI = intermediated water immersion (28°C), HWI = hot water immersion (38°C), CN = control (no water immersion). The HR was at the end of exercise (post) and during recovery (3, 6, 9, 12, and 15 min) is represented. *P = 0.000, compared to the other conditions. **P = 0.000, CWI versus CN and IWI.
CONCLUSIONS

As expected, post-exercise recovery by water immersion influenced mean skin temperature and HR. However, EPOC and blood lactate levels were not affected by water immersion, thus indicating that water immersion does not improve exercise recovery. These findings do not support the use of water immersion to improve exercise recovery.

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Address for correspondence: Etel Rocha-Vieira, PhD, Federal University of Jequitinhonha and Mucuri Valleys. Diamatina, Minas Gerais, Brazil. 39.100-000. +55 38 35321235. etelvieira@terra.com.br

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