Which Temperature During the Water Immersion Recovery Is the Best after a Sprint Swimming?

Zeinab Rezaee, Fahimeh Esfarjani and Sayed Mohammad Marandi

Abstract: The aim of this study was to investigate the effect of water immersion at different temperatures on fatigue and sprint swimming. Ten elite women swimmers, age (17.8±2.2), three times a week in 48-h intervals completed two 100-m front crawls (S₁ and S₂) interspersed with a 15-m recovery period consisting of: contrast water therapy (CWT, alternating hot 40 degrees C, 2 min /cold 23 degrees C, 1min), cold water immersion (CWI, 23 degrees C) and hot water immersion (HWI, 40 degrees C). Before and after S₁ and S₂, and every three-min during the recovery, skin temperature, blood lactate and heart rate were recorded. After the recovery, level of fatigue evaluated via TQR questioner, then participants performed (S₂) and ultimately recorded the rate of perceived exertion through RPE questioner. Results showed that heart rate significantly decreased after CWI toward other groups. After CWT and CWI, skin temperature decreased significantly. Lactate removal was largest in CWT compared to the HWI. Both CWI and CWT were associated with improvement in swimming performance and following these methods TQR and RPE evaluated better than HWI (p<0.05). It seems CWT and CWI can be used in repeated high intensity interval performance with short recovery.

Key word: Lactate · Cold water immersion · Repeated swimming · Heart rate

INTRODUCTION

Recovery from exercise involves the return of the body from a fatigued state to its normal physiological and performance baseline. Optimization recovery post-game or post-recovery could provide a competitive advantage to an athlete, especially if more than one bout of exercise is performed in a day [1]. In this situation the recovery process becomes more critical as there can be inadequate time available to fully recover from a fatigued state before the next bout of exercise [2]. However, if the athlete failed to recovery from daily exhaustive training and competition, inadequate recovery may lead to poor performances, burn-outs, sicknesses and even injuries [3]. During swimming competitions, athletes can be required to repeat maximal performances within a short period of time (<30 min) [4]. Different recovery strategies are used by athletes during competition and training to enhance recovery [5]. Throughout history immersion in hot and/or cold water has been used as a therapeutic treatment for restoring physical and mental health, but nowadays it is used as a recovery strategy [6] and become popular recovery modalities that recently were lionized by athletics and coaches [7]. Water immersion is similar to the mechanisms attributed to active recovery without any extra energy cost involved. Also the heat dissipation capacity of water is considerably greater than that of air, as the ratio of heat conductivity of water to air is approximately 24:1 [1]. So it can enable the body to recover faster and also the body would be able to replenish energy reservoirs, more effectively [8]. Water temperature rather than water immersion itself maybe the major factor in any benefit to performance recovery and at different temperature in species sports found various results. Some researchers showed that water immersion maintained performance and reduced fatigue. Therefore, this method could be beneficial for sports that are repeated several times in a day such as volleyball, rugby and swimming [1].

Increasing body temperature after an activity has negative effects on the body such as: disturbing muscle strength, carbohydrate metabolism, blood flow in the body, delivering oxygen to different parts and other physical processes. So any method that can reduce body
temperature will have a positive impact on the next performance [9]. Even if the increase in core temperature is not significant, lowering skin temperature through various methods, leading to relaxation and stress reduction due to activity and competition, so cold water immersion can be useful. Versus, some researchers have reported that this method of immersion reduces flexibility and range of motion, therefore will decrease the next performance [10]. Howard et al. (1994) observed significant reduction in higher-velocity isokinetic torque after cold water immersion (12°C) but not following thermo-neutral immersion (11). Whereas, Ingram et al. (2008) reported that immersion in cold water (10°C), facilitated exhausting performances and improved recovery rather than contrast water therapy (12). Vail et al. (2008) reported, the cold water immersion and contrast water immersion, maintained performance and improved recovery from high-intensity cycling compared to hot water immersion [13].

Hot water immersion produce a rise in sympathetic power and sympathovagal balance from baseline, reduce stress and anxiety and enhance relaxation and meditation [14]. It can be effective in removing the unwanted metabolic substances by reducing spasm, increasing the muscular elasticity, increase in cardiac output and blood flow, but simultaneity, increase the heart rate and the skin temperature [1]. So far, most research investigated the effect of hot water immersion on long and heavy activity and not found positive effect of this method on recovery and performance [15, 16], also its effect on immediate sprint performance is not reported.

Previous research focused on investigation the effect of water immersion on repeated aerobic performance [7, 16, 17], but has received less attention on short (i.e., <2 min) and maximal efforts. Some studies have investigated the effect of CWI on repeated high-intensity cycling performance [10, 18, 19], they have reported mixed results and little studies has investigated the impact of CWI on repeated sprint swimming performance [16, 20]. Most water immersion studies have concentrated on the physiological effects of immersion. Research on the effects of water immersion models on performance has produced conflicting results [13]. Due to the lack of research on water immersion, especially on women swimmers, this study investigated effects of water immersion methods in different temperature on some physiological, psychological responses and subsequent performance in elite female swimmers.

**MATERIALS AND METHODS**

**Participants and Recovery Intervention:** Ten elite woman swimmers, age (17.8±2.2), height (164.5±5.8 cm), weight (59.2±9.9 kg) completed three experimental trials at the same time of days with at least 48 hrs distance. The study was supported by research ethics. To eliminate any time effects and complications, we conducted all measurements and evaluations at a fixed time in the evenings. Subjects performed two 100-m front crawl interspersed with 15 min differing recovery intervention: contrast water therapy (CWT) (alternating hot 40°C, 2 min /cold 23°C, 1min), cold water immersion (CWI)(23°C) and hot water immersion (HWI)(40°C). Participants were submerged and only their head remained above the water. Blood lactate, heart rate and skin temperature were recorded before and after 100m and every three minutes during recovery. After the recovery, participants completed TQR questionnaire to evaluate the quality of recovery [21], then repeated 100m front crawl and finally completed RPE questionnaire for assessment rate of perceived exertion and fatigue.

**Selecting Water Temperature for Recovery:** Many researchers have investigated the effect of water immersion recovery on men, but there are main differences in physiological responses between the two sexes as anthropometric characteristics, smaller muscles in the women and so lower metabolic products in women. Temperature of the cold water immersion was reported (10-15°C), but in this study we selected balanced cold water that has been reported between (16-23°C) [7, 22].

**Heart Rate Evaluated:** Heart rate was recorded with a water proof Germany Pulsometer in rest, immediately after the S, every three minutes during the recovery and after 1S.

**Blood Lactate Concentration:** Resting La, 3 min after S, and S, and each three minutes through recovery period fingertip capillary blood sample (5µL) was collected and analyzed by Germany Lactate Scout Lactometer.

**Skin Temperature:** $T_{sk}$ measured using four re-usables points of the body consisting of right calf, right thigh, right forearm and chest then calculated with the following equation:

$$T_{sk} = (0.3\times(\text{chest + forearm})) + (0.2\times(\text{thigh+ calf}))$$ (10)
was recorded by infrared terminator monitor in rest, 3 minute after S1 and S2 and also at the end of recovery.

Rating of Perceived Exertion and Total Quality of Recovery: Immediately after the recovery, the participant’s rating of total quality of recovery was evaluated on a (6–20 scale), with a rating of ‘0’ feeling ‘not recovered’ and a rating of ‘20’ feeling ‘fully recovered (21). Participants also indicated their rating of perceived exertion (RPE 6–20 Borg scale) at the end of S2.

100 m-front Crawl Swimming Performance Test: Participants completed two maximal 100-m front crawl swimming sprints separated by a 15-min recovery each day. Time was measured with a Casio recorder. Participants were instructed to complete each sprint as fast as possible.

Statistical Analyses: All experimental and calculated values are presented as mean +/- standard deviation. Results between recovery conditions were analyzed with repeated measures with Fisher's LSD being used for post hoc analysis. In all statistical analyses, the threshold for significance was set at (p<0.05). All data were analyzed using the SPSS version 16.0.

RESULTS

The Effect of Recovery Intervention on Physiological Responses: Skin temperature following the CWI and CWT decreased significantly compared to HWI (Table 1). After CWI, heart rate decreased significantly toward HWI (Figure 1). Immersion conditions reduced Lactate concentration, but this reduction was significantly higher after the CWT toward the HWI (Figure 2).

Table 1: Schematic representation of the protocol

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>Measuring in recovery</th>
<th>Recovery methods (15 min)</th>
<th>Recorded TQR</th>
<th>Second Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHR, Tsk, La</td>
<td>La, HR</td>
<td>First method cold water therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100_meters</td>
<td>front crawl</td>
<td>2nd method cold water therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1, S2, S3</td>
<td>Hot water immersion</td>
<td>3rd method hot water therapy</td>
<td></td>
<td></td>
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</tbody>
</table>

Table 2: The effect of recovery interventions on performance, TQR and RPE

<table>
<thead>
<tr>
<th>Factors</th>
<th>CWT</th>
<th>CWI</th>
<th>HWI</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 m-front crawl swimming (X (min) ± SD)</td>
<td>1.24 ± 0.06</td>
<td>1.23 ± 0.07</td>
<td>1.23 ± 0.05</td>
</tr>
<tr>
<td>TQR After recovery</td>
<td>Very good (17.8)</td>
<td>Very good (17)</td>
<td>Good *(15.4)</td>
</tr>
<tr>
<td>RPE After S1</td>
<td>Fairly light</td>
<td>Fairly light</td>
<td>*Somewhat hard</td>
</tr>
<tr>
<td>Skin temperature (°C)</td>
<td>Rest: 1.2± 32.9</td>
<td>1.2± 33.6</td>
<td>1.2± 32.1</td>
</tr>
<tr>
<td></td>
<td>After S1: 1.3±34.6</td>
<td>1.4± 35.3</td>
<td>1± 34.2</td>
</tr>
<tr>
<td></td>
<td>After recovery: 0.8± 31.4</td>
<td>0.6± 30.2</td>
<td>0.8± * 35.7</td>
</tr>
<tr>
<td></td>
<td>After S2: 1± 33.1</td>
<td>0.4± 32</td>
<td>0.8± * 37.3</td>
</tr>
</tbody>
</table>

*Significant difference between CWI and CWT. X: mean. SD: Std. Deviation.
DISCUSSION

The present study examined the effect of three water immersions recovery on fatigue and sprint swimming performance using a protocol that replicates the conditions swimmers encounter during competitions. Findings show that pre- and immediately post-exercise physiological responses were not different between recovery methods in three days, so participant performed S, with maximal power and speed in. Following CWI, the heart rate was significantly reduced compared with HWI. Vaile et al. (2008) and Crowe & Rudd (2007), supported the present study on sprint cycling [13, 19]. Whereas, Bolster et al. (1999) found that following the CWI, the heart rate increased [23]. It seems that following immersion at 12–15°C, heart rate increased to maintain body temperature.

Generally, water immersion produced increasing in central blood volume expansion that associated with an increase in cardiac pre-load. Central blood volume expansion increased arterial pre-load and stroke volume. Increasing mean arterial pressure causes arterial bar receptors to bring about a reflex to slow the heart rate [1]. So the effort required to circulate blood decreases while cardiac efficiency increases [14].

The rapid decrease in skin temperature observed at the start of CWI and CWT. Many researchers found similar results [7, 10, 24]. This result would have elicited as a vasoconstrictive response of peripheral blood vessels. Increase in body temperature after exercise, increased sweating, dehydration, increased fatigue and lack of preparation for the next optimal performance. Therefore, CWI and CWT reduced skin temperature because of peripheral blood flow temperature is reduced before it reaches the central organs [7, 10]. On the other hand, increase in blood flow and stroke volume can be assumed for decreasing heart rate and skin temperature after CWI [6]. HWI increases the heart rate which is associated with the increase in skin temperature [14]. So HWI were not beneficial effects on skin temperature.

Since water immersion conditions increases the central blood volume thus body fluid shifts would increase between intracellular-intravascular space caused rapidly clearance of metabolic wastes such as lactate after immersion toward land [6]. In this study the rapid decrease in blood lactate observed at the start of CWT and observed significant difference toward HWI. Buchheit et al. (2010) and Mortone (2007), also reported similar findings following the sprint swimming and wingate test [20, 25]. It seems CWT also provides neural stimulation because the central nervous system received two different types of information: hot and cold [12]. Alternating muscular contractions acting in a pumping/squeezing action can be caused muscles contraction-relaxation and increased lactate removal. Compared with HWI condition, it was expected that CWI to accelerate blood lactate clearance [1].

The important point in the present study is significant differences in the blood lactate removal at the 9th min of recovery between CWT and HWI and significant decreases in heart rate at the 6th min of recovery between CWI and HWI. Fabrizio et al (2007) found similar results in comparing cycling water immersion and cycling in land after a similar exercise bout [9]. So, these methods can be useful in short time recovery between interval performances.

CWT and CWI conditions improved TQR compared to HWI. Buoyancy reduced musculoskeletal systems acting, so greater relaxation would appear to reduce perceived fatigue [7]. It is also possible that the increased parasympathetic activity following CWI and its reciprocal reduced sympathetic over-activity contributed to greater feelings of well-being [26]. Immersion in warm water is generally found to be pleasurable, creating an almost universal feeling of relaxation [14]. And CWT via rapid change from hot to cold produced natural massage for muscles [6]. Finally, RPE decreased significantly after CWT and CWI compared to HWI. These observations are consistent with previous findings on 30s maximal cycling effort [18, 19] and anaerobic freestyle swimming [20]. It could be hypothesized that since the sprint is maximal in all conditions, perception of exertion is also consistently maximal [4]. So, water immersion recovery suggested in these states. It seems in our study, because of increasing in heart rate and skin temperature after the HWI, subjects didn't have satisfaction and good feeling due of this way.

Both CWI and CWT improved significantly subsequent swimming performance. This result is supported by some researches [4, 12, 20] that they found these interventions maintained greater aerobic performance. This critical finding has been proposed to be related to reduced T_d [6, 7] improvement in La removal [1], as well as an increase in TQR [6]. However, repeated high-intensity cycling performance [18, 19, 27] and sprint swimming [4] were shown to be reduced following 15 min of CWI. It was hypothesized that very low water temperature (10 –15°C), has detrimental effect on HR, muscle temperature and inhibitory effect on nerve conduction as well as effect on force production [5]. Therefore, the temperature of water used in the immersion studies could have some direct influences on findings.
In conclusion, quicker recovery from fatigue has potential benefits in that it allows athletes to train or compete at a higher intensity and could provide a competitive edge [2, 28]. However, in previous study range of cold water temperature, is very low (10-15°C), but the present study showed that temperature of 23°C, also can be appropriate.

Hence, contrast water therapy and moderate cold water immersion increases athletic recovery through stimulating area specific blood flow, increasing blood lactate removal, reducing skin temperature and improving the quality of recovery, so can be beneficial on repeated anaerobic swimming performance.

REFERENCES