Effects of Cold-Water Immersion to Aid Basketball Athlete’s Recovery after High Intensity Interval Training

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Abstract
Cold Water Immersion (CWI) is associated with vasoconstriction and a relative decrease in blood flow. The purpose of this study was to examine whether CWI was an effective tool to aid in the recovery of male basketball players. Overall, 26 male basketball athletes from UNJ Basketball Club volunteered to be the subjects of this study. The participants were randomized into 2 groups: 13 were assigned to the experimental (CWI) group, and the other 13, in the control group, were given slow jogging recovery (SJR). Both of the group required to complete High Intensity Interval Training (HIIT). Furthermore, each group completed tests pre- and post-recovery for physiological measurements (blood lactate) and performance measurements (VJ). For lactate-post-recovery, ANOVA revealed significant among CWI and SJR groups (p=0.001). There was no significant among CWI and SJR groups in VJ-pre (p=0.380) or VJ post (p=0.021), respectively. We demonstrated that CWI after HIIT had an effect on the recovery of elite basketball players by decreasing the lactate concentration, but no performance improvements of VJ were observed.

Keywords: Blood lactate, Basketball, Training, Muscle, Recovery

Introduction
As a team sport, basketball is a sport that’s quite popular in the world (Nabli, et al., 2019). In its development, basketball has become one of the sports played at the Olympics since 1936, and has become one of the mainstay branches of several countries to get high-level achievements in the event (Esteves, Mikolajec, Schelling, & Sampaio, 2020). Because of this, it is not surprising that many coaches, sports scientists or other stakeholders, are competing to develop the technical, physical, and tactical abilities for every basketball athlete they have in each of their countries (Maimon, Courcél-Îbáñez, & Ruiz, 2020).

Several previous studies have revealed facts related to basketball games (Clemente, Sanches, Moleiro, Gomes, & Lima, 2020). Basketball itself is a sport that has characteristics of high intensity play, with 75% playing time, basketball athletes are at > 85% of their maximum heart rate. In this context, coaches and basketball athletes used many strategies recovery, in order to maximize training and preparing athlete’s performance for the next match by recovering as fast as possible (Benson, et al., 2020).

Experts now divide recovery process into categories such as; active, and passive recovery. Sports scientist, coaches, and athletes believe recovery process will minimising the effects of fatigue and allowing athletes to train and compete optimally (Laffaye, Silva, & Delafontaine, 2019). Specifically, in a few of sports scientific literature, the efficacy of several recovery methods has been analysed and discussed, such as massage, stretching, compression, low-intensity aerobic activity, neuromuscular electrical stimulation, and hydrotherapy (Aho, Hlavainen, Kyrolainen, & Mero, 2019). While, there has been an ongoing debate regarding which recovery methods is the most efficient to accelerate athlete’s recovery (Kellmann, et al., 2018).

According to a few literatures, hydrotherapy is the broad term encompassing hot water immersion (HWI; ≥36°C), contrast water therapy (CWT; alternating CWI and HWI), thermeutral water immersion (TWI; from > 20°C to ≤36°C), and cold water immersion (CWI; ≤20°C) (Vaile, Halsen, Gill, & Dawson, 2008). As a part of the hydrotherapy method, CWI is the one recovery method that widely used by athletes. Furthermore, (Hoehnauer, et al., 2019) explained that CWI will aid the recovery process by vasoconstrictive effect and reduction of inflammation and metabolism. Because of this theory, some of the previous studies have been observed the benefit of CWI as a post-exercise recovery (Halsen, Marc J Quod, Gardner, Ebert, & Laursen, 2008).

To our knowledge, there are only a limited number of human studies, which have focus on examined and observed benefits of CWI in basketball athletes (Junior, et al., 2011). Therefore, the
purpose of this study was to examine whether CWI was an effective tool to aid in the recovery of male basketball players. We specifically addressed the effects of CWI on blood lactate and vertical jump performance (VJ). We hypothesized that CWI might reduce the lactate concentration and also would significantly increase performance for VJ compared with a control group.

Material and Methods

Participants

Overall, 26 male basketball athletes from Universitas Negeri Jakarta (UNJ) Basketball Club volunteered to be the subjects of this study. All participants were asked to fill in a health questionnaire, and recruited based on the following criteria: They did not have any smoking history. All participants played basketball for at least 5 years with three or more training sessions per week, each lasting 3 hours. Exclusion criteria involved a cardiovascular or respiratory disease, and if the subjects had lower- and upper extremity injuries or musculoskeletal injuries within six months prior to the initial testing. All included participants were fully informed about the aims and risks of this study, as well as the discomforts related to this study, before signing an informed consent form. All of the procedures were approved by the ethics committee of the ethics committee of Universitas Negeri Jakarta.

Experimental Overview

The study used a randomized controlled, parallel group design. The methodological design was based on previous human studies (Hohenauer, et al., 2019). The participants were randomized into 2 groups: 13 were assigned to the experimental (CWI) group, and the other 13, in the control group, were given slow jogging recovery (SJR). Each group completed tests pre- and post-recovery for physiological measurements (blood lactate) and performance measurements (VJ). Additionally, all of the subjects were familiarized with each exercise testing protocol separately.

Experimental design

After enrolment, participants were randomly allocated into either the CWI and SJR groups. Immediately after, anthropometric was measured. The body weight and body fat percentage were measured on OMRON HBF-375 Karada Scan Body Composition Scale, with participants wearing minimal clothes and being barefoot. The body height was measured with a stadiometer with 0.1 cm readability (Seca 214 Portable Stadiometer, Cardinal Health, Ohio, USA) according to the described standardized procedures. The body mass index was calculated as the ratio of the body mass (kilograms) divided by body height (metres) squared.

After the anthropometric measurements, a 100-μl sample of fingertip capillary blood was obtained and a 5 μl sample of venous blood was drawn from the medial cubital vein to measure lactate-pre. Participants required performed a standardized 6-min warm-up prior to the VJ test and high intensity interval training (HIIT) session. HIIT was an interval exercise consisting of sprinted with a track distance of 25 m. Starting the test, the participant should ready themselves in a “standing start position” at one end of the 25 m sprint track (i.e. cone A), and then the participant sprints to the end of the 25 m track (i.e. line B) touched a line with a foot and then came back to the starting line. With three series of two 1-min repetitions at 90% heart rate intensity (3x2x1-min), with recoveries at 130 bpm between repetitions and at 120 bpm between series.

Immediately after the HIIT session, all participants assigned to their recovery interventions, based on each group. Lactate-post were measured immediately after the end of the last task section. Furthermore VJ-post initiated 24 h after the final day of recovery interventions, and always measured in the aforementioned order.

Vertical Jump (VJ)

The vertical jump test was administered according to the guidelines proposed by (Monks, Seo, Kim, Jung, & Song, 2017). Vertical jump test was measured on Vertec polymers, Houston, TX, USA. Vertec is a construction with horizontal vanes and each vane is 1-inch increments. The lowest vane was adjusted to be at the point of the longest finger with the arm fully extended and both feet on the ground, the jump height was simply the highest vane reached. The participants leapt vertically as high as possible using both arms and legs to assist in projecting the body upwards. A practice jump was

ISSN: 2005-4238 UAST
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2053
performed to familiarize the participants before the recorded jumps. The maximum value of these 3 attempts was used to assess VJ.

**Blood sample analyses**

A 100-μl sample of fingertip capillary blood was obtained to measure lactate pre-recovery, post-recovery (immediately after HIIT). The blood samples were analysed with a Lactate Pro analyser (Arkray, Shiga, Japan).

**Recovery interventions**

The participants were divided into the CWI group and the SJR group, to receive the following recovery procedures. Recovery for the CWI group consisted of periodic immersions in cold water (16 °C and the water was maintained at a mean temperature by the addition of crushed ice) for 7 min. During the time of CWI, participants in the CWI group remained in the seated position and immersing their lower limbs in a water bath at a mean temperature of (water temperatures were measured with a Testo AG T 106 thermometer). The subjects were passive during the water immersion. In turn, recovery for the SJR group included 8 min of slow jogging (6.8 km·h⁻¹) around a field. The jogging speed was controlled via verbal feedback of lap times.

**Statistical Analysis**

The values are presented as mean ± SD. Normal distribution of the sample was checked using the Shapiro–Wilk test. The repeated measurement, ANOVA and Independent t-test were used to evaluate each parameter. Independent t-test was used to determine any differences among pre- and post-recovery in each group. The 95% confidence interval (CI) and percent changes were calculated. Statistical significance was accepted at the p<0.05 level. Performed by using the SPSS software, V.21.0.

**Results**

To reveal the differences in (blood lactate) and performance measurements (VJ) among CWI group and SJR group used the One-Way ANOVA (see Table 2).

<table>
<thead>
<tr>
<th>Variables</th>
<th>CWI Group</th>
<th>SJR Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>18.6±0.48</td>
<td>18.6±0.47</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>73.0±6.42</td>
<td>68.3±5.78</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>175.5±4.96</td>
<td>173.5±4.74</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.8±2.25</td>
<td>22.6±1.71</td>
</tr>
</tbody>
</table>

**Table 2.** The effect of Cold-Water Immersion.

<table>
<thead>
<tr>
<th>Variables</th>
<th>CWI Group</th>
<th>SJR Group</th>
<th>ANOVA p values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactate-pre</td>
<td>1.45±0.32</td>
<td>1.35±0.29</td>
<td>0.206</td>
</tr>
<tr>
<td>VJ-pre</td>
<td>16.42±2.45</td>
<td>13.57±2.20</td>
<td>0.380</td>
</tr>
<tr>
<td>Lactate-post-HIIT</td>
<td>11.75±1.48</td>
<td>12.08±0.75</td>
<td>0.622</td>
</tr>
<tr>
<td>Lactate-post-recovery</td>
<td>2.59±0.57</td>
<td>3.90±1.15</td>
<td>0.001*</td>
</tr>
<tr>
<td>VJ-post</td>
<td>16.40±2.76</td>
<td>13.20±2.45</td>
<td>0.021</td>
</tr>
</tbody>
</table>

**Abbreviations:**
Lactate-pre, measured blood lactate before HIIT; VJ-pre, measured vertical jump before HIIT; Lactate-post-HIIT, measured blood lactate after HIIT; Lactate-post-recovery, measured blood lactate after recovery interventions; VJ-post, measured vertical jump after 24-hour recovery interventions;

**Blood Lactate**

Based on lactate-pre measurements, one-way ANOVA statistical test results showed no significance among CWI and SJR groups (p=0.260). There was also no significant in lactate-post-HIIT between CWI and SJR groups (p=0.622). Significant results had only been seen in lactate-post-recovery, with ANOVA revealed significant among CWI and SJR groups (p=0.001).

**Vertical Jump (VJ)**

On vertical jump measurements, there was no significant among CWI and SJR groups in VJ-pre (p=0.380) or VJ post (p=0.021), respectively.

**Discussion**

The purpose of this study was to examine whether CWI was an effective tool to aid in the recovery of male basketball players. With respect to prior hypothesis, it is stated that CWI recovery consisted of periodic immersions in cold water (16 °C and the water was maintained at a mean temperature by the addition of crushed ice) for 7 min could have a significant effect in reducing blood lactate concentration. This represents an important fact because the CWI as a recovery method to reducing blood lactate concentration, really important in intermittent characteristics sports such as basketball.

**Conclusion**

Our results showed that CWI after high intensity interval training had an effect on the recovery of elite basketball players by decreasing the lactate concentration. Furthermore, no performance improvements were observed. Further study is needed to conduct the mechanism behind the decline in blood lactate concentration and to rectify the discrepancies found in the results of some studies.

**Acknowledgments**

The authors would like to thank the Universitas Negeri Jakarta for providing data for the study.

**References**


a. No financial support was required or provided for this study.