Changes in blood pressure, heart rate and perception of fatigue in Recovery to primary active state in water with three different temperatures, after an exhausting activity

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Abstract

The present study aims to compare the effects of different temperatures of water on systolic and diastolic blood pressures, heart rate and perception of fatigue when returning to the primary active state, after a 200-meter front crawl swimming. Thus, 13 female students with a mean age of 21.84 ± 1.86 years, height of 162 ± 3.85 cm and weight of 57.46 ± 8.44 kg were voluntarily chosen and swam 200 meters front crawl in three different days within a week and then they attended in one recovery method for 5 minutes including, walking slowly in cold water, (20°C), walking slowly in warm water (39°C) and walking slowly in mild water (28°C). In order to evaluate data, repeated measurements and Bonferroni test were used. Results showed that the recovery in cold and mild water shows the greatest reduction in heart rate (p = 0.001) compared to warm water and there is also a significant difference in the recovery in mild and warm water (p=0.03). Systolic blood pressure in warm water was the lowest compared to other two methods after recovery to the active state (p=0.009) and diastolic blood pressure had the maximum reduction in warm water (p=0.017). Recovery to the primary active state in cold water significantly increased perception of fatigue in comparison to other methods (p=0.009).

Keywords: recovery, blood pressure, perception of fatigue, heart rate.

Introduction

The recovery period after exercise is an important performance factor in the repetitive exercises. In tournaments, when athletes compete several times during a few days, their rapid recovery can provide an advantage for them. An optimal method for the recovery after exhausting activities is water exposure. Water may cause physiological changes in the body that can improve the recovery (Wilcock,2006) and it is an effective factor for the activity of the parasympathetic system during the recovery period (Buchheit et al.2009), immersion in cold water can cause significant biochemical and physiological changes in the body during recovery after exercise, but their physiological and biochemical effects after exercise are still controversial and there is no clear instruction for their use (Bleakly and Davison,2010). To achieve maximum athletic performance, always may be a proper balance between training, competition stress and recovery (Anthony,2006). Returning to the initial state depends on the nervous, cardiovascular and metabolic changes. Immersion in the water is a simple and efficient method for the rapid stimulation of the parasympathetic system after practice, and it seems that colder water is more effective in increasing parasympathetic activity (Haddad et al, 2010). However, using cold water in recovery has scientific evidences, but the precise physiological responses in cold water compared to warm water is not clearly defined yet (Peiffer et al,2008).

One of the important factors during exercise is athlete systolic and diastolic blood pressure change (Van Voorhees et al. 2007). Blood pressure is continuously changing to maintain homeostasis in the body. As temperature changes can disrupt homeostasis, we anticipate that blood pressure is effective in the regulation of body temperature, leading to increased blood pressure when low temperature and low blood pressure when the temperature increases (Gardner et al, 2007). History of water for medical purposes dates
back hundreds of years ago, but in the past few years, immersion in water has been considered more in advancing medical purposes and it is one of the most attractive methods of recovery. Water temperature changes and physiological responses to immerse in warm water, cold water, mild water and alternative immersion in cold/warm water can create a suitable range for water temperatures in the recovery. The methods difference is the difference between water temperatures and different results are obtained at different temperatures (Wallman et al, 2004. Wilcock, 2005).

Methods and Materials

The present study is quasi-experimental. The research sample consists of 13 female students of physical education major in Shahid Chamran University, the average age, weight and height are 21.84 ± 1.86 years, 57.46 ± 8.44 kg and 162 ± 3.85cm respectively, which are purposely selected among qualified candidates. The study was performed on three separate days with one-week interval. Tests were done in the specified days at 10:30 to 12:00 and in 28 °C in an indoor pool. Recovery was done through three floating methods, in the mild water (28 °C), warm water (39 °C) and cold water (20 °C) after every 200-meter front crawl swim. Before swimming, subjects’ heart rate and blood pressure were recorded and after swimming, at 2 and 4 minutes of recovery heart rate and blood pressure were again measured and recorded. The subjects filled the perception of recovery questionnaires in minute 5 of the recovery period.

The questionnaire included four questions and responses were in the range of zero to seven. The questionnaire had an internal validity of 0.86 and external validity of the questions have been confirmed by physical education and sport science experts in England (Hemmings et al, 2000). For research data analysis, descriptive statistics (mean, variance, and standard deviation) and inferential statistics (paired comparison test to compare different times in the three recovery test methods and repeated measurements to compare times in all three recovery methods) were used and Excel software was used to draw graphs.

Results

The variables were measured in pre-test and post-test to ensure that the observed differences in research dependent variables changes are due to different methods of recovery, not the primary differences in dependent variables, and there were no significant differences between variables.

Table 1. Results of repeated measurement tests to compare the study variables after three methods of recovery

<table>
<thead>
<tr>
<th>Variable</th>
<th>Conditions</th>
<th>sample number</th>
<th>mean</th>
<th>Standard deviation</th>
<th>Significant level (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats per minute)</td>
<td>Warm</td>
<td>13</td>
<td>112</td>
<td>2.16</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Cold</td>
<td>13</td>
<td>98</td>
<td>2.48</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>mild</td>
<td>105</td>
<td>2.33</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warm</td>
<td>105.61</td>
<td>2.85</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>Cold</td>
<td>13</td>
<td>117</td>
<td>3.53</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>111.69</td>
<td>3.02</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warm</td>
<td>62.15</td>
<td>3.89</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>Cold</td>
<td>13</td>
<td>73.15</td>
<td>5.2</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>77.92</td>
<td>3.13</td>
<td>0.017</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warm</td>
<td>17.61</td>
<td>0.71</td>
<td>0.017</td>
<td></td>
</tr>
<tr>
<td>perception of recovery (score)</td>
<td>Cold</td>
<td>13</td>
<td>23.30</td>
<td>0.55</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>19.92</td>
<td>0.66</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>

According to Table 1, the lowest heart rate after the recovery in cold water was averagely 98 ± 2.48 beats per minute and the lowest reduction was averagely 112 ± 2.16. There was a significant difference between heart rate after three methods recovery, post hoc test results showed a significant difference between heart rate in cold and warm water (p = 0.01). It means that there was a greater decrease in heart rate in cold water. Also, the difference between heart rate after the recovery in mild and warm water was significant (p = 0.03).

According to Table 1, systolic blood pressure with average of 105.61 ± 2.85 mm Hg after the recovery had the largest decline in warm water (p = 0.009); diastolic blood pressure with average of 62.15 ± 3.89 mm Hg had the sharpest decline after the recovery in warm water (p = 0.017).
According to Table 1, the highest score of the recovery perception in cold water was averagely 23.30 ± 0.55 and the lowest the recovery perception in warm water was averagely 17.61 ± 0.71; there was a significant difference between the score of the recovery perception in the three methods (P = 0.001). Bonferroni test results showed that there was a significant difference (p = 0.001) between the amount of the recovery in cold water and warm water, (increase in the recovery in cold water). The recovery in mild water was significant compared with warm water, as well (p = 0.001). Recovery in mild water caused more increase in recovery perception than warm water.

Discussion

The purpose of this study is to compare the effects of the recovery (walking slowly) in cold, warm and mild water on changes in blood pressure, heart rate and perception of recovery after 200 meters front crawl swimming. Data showed that both systolic and diastolic blood pressures had a greater reduction in warm water. These findings are consistent with results of previous studies in which immersion caused a decrease in peripheral resistance due to reduced cardiac work necessary to increase the blood flow (Becker et al, 2009. Arborelius et al 1972). For example, (Hildenbrand et al, 2010) investigated the effect of youth immersion in water. Results showed that change in systolic and diastolic blood pressure was more during the immersion in the warm tub. In the research conducted by Gardner et al, 2007) blood pressure was higher after exposure to warm temperatures, while heart rate did not differ at different temperatures, indicating that blood pressure helps body heat loss and maintains homeostasis without increasing heart rate. Results of this study showed that heart rate reduced in cold, warm and mild water and cold water had the most decrease in heart rate, this was not consistent with the results of Sramek et al (2000) study in which immersion in warm and mild water decreased heart rate, but heart rate increased in cold water. May be, the reason for the difference is using different exercise protocols before different methods of recovery. Sramek et al did not use exercise protocols before the immersion in water with different temperatures, while in the present study, the subjects were swimming 200 meters before recovery. Also, it is not consistent with research results of Yeargin et al (2006) and Bolster, et al (1999) in which subjects were recovered between temperature 10 to 15 °C, while in this study recovery was done at 20 °C. So, the reason for the discrepancies could be difference in temperatures. When immersing in water with increased mean arterial pressure, pressure receptors in arteries send negative feedback and cause reduction in sympathetic activity and thus the diameter of the vessels and blood volume in muscles will be increased, blood pressure and heart rate are reduced and the recovery of peripheral nervous system will be improved (Morton, 2006. Calder, 2003). The findings of research are consistent with results of Crowe et al (2007), King and Duffield (2009), Hamlin (2007), Buchheit et al. (2009), Haddad et al (2010), Nakamura et al (1996). Water immersion is a simple and efficient mean for stimulating the immediate parasympathetic activity and reducing sympathetic tone after exercise, and it seems that colder water is more effective on increasing parasympathetic activity (Miyamoto, 2006). Parasympathetic nervous system activity after the recovery in cold water is higher than warm water (Haddad et al, 2010). So, it can justify faster decrease in heart rate after the recovery in lower water temperatures.

Using the recovery perception questionnaire, results showed that three methods of recovery in cold, warm and mild water caused swimmers relaxation, but the feeling of the recovery in cold water represents more efficiency than warm and mild water. Findings of this study about the perception of fatigue agree with results of the active recovery of Kinugasa, and Kilding (2009). In these studies it was shown that the combined method of cold water along with activity is more effective on increasing the subjects’ perception of recovery compared to other methods. Similarly, from the results of Stanley et al (2011) and Poumot et al (2011) we can conclude that the recovery in the water has an effect on perceived recovery especially in cold water. Recovery in the water after exercise causes reduction in blood lactate concentrations and a significant positive relationship exists between disposal of blood lactate and perceived recovery (Coffey et al, 2004. King and Duffield, 2009).

Conclusion

Given the significant impact of recovery (walking) in water especially cold water on heart rate and also subjects’ opinions, it is recommended to athletes, especially those who have to race in some days and also to coaches to use the recovery methods in water, especially in cold water in the repeated exercise periods.

Acknowledgement

The authors wish to thank all the students who helped the fulfillment of the present investigation, through their kind participation in the current research.
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