

## Effect of cold water immersion on exercise induced-inflammation

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### Abstract.

*Introduction:* Immersion in cold water has been used as a therapeutic treatment for restoring physical activity and mental health. The effect of this method on reduction of exercise induced-inflammation is not well known. The aim of this study was to investigate the effect of cold water immersion on CRP levels after an exhaustive aerobic training.

*Material & Methods:* 20 male table tennis athletes were participated in this study as the subjects. The subjects were divided into the passive recovery (n=10) or cold water immersion (n=10) groups. All the subjects were performed the Bruce test protocol as the exhaustive aerobic training. Blood CRP was measured at three times: before and immediately after the exhaustive aerobic training and after the recovery strategies.

*Results:* The results showed that the CRP levels increased immediately after the exhaustive aerobic training in the two groups ( $P < 0.05$ ). Blood CRP levels decreased after 15 min passive recovery and cold water immersion compare to after the exhaustive aerobic training ( $P < 0.05$ ). Bonferroni Post hoc test indicates that no significant differences were observed between two types of recovery.

*Conclusions:* The results suggested that no significant differences are exist between the passive recovery and cold water immersion on reduction of exercise-induce inflammation; thus these two strategies are well for CRP reduction after intensive exercise.

**Key words:** Recovery, Inflammation, Water immersion, Exhaustive training

## 1. Introduction

Unaccustomed and high-intensity exercise may result in significant damage to skeletal muscle and cause delayed onset muscle soreness and inflammation in both recreational and elite athletes (1). CRP is a commonly used marker of systemic inflammation (2) that has also been used to investigate the level of inflammation post-exercise (3,4). A large amount of therapeutic modalities are used after sports activities to improve skeletal muscle recovery, the most commonly used modalities are: active recovery (5,6), cold water (cryotherapy) (7), massage (8), contrast heat therapy (use of hot and cold water immersion) (9-11), hydrotherapy (12), stretching (13), and electric stimulation (14). However, the scientific evidence behind these modalities is limited.

Water immersion is the one of recovery strategies that gaining popularity among athletes. Immersion in hot and/or cold water has been used as a therapeutic treatment for restoring physical and mental health (15). After training or games some athletes may spend up to 20 minutes using water immersion to enhance recovery (16). In this method, the pressure of water on the body causes a redistribution of body fluid with increasing levels of immersion increasing the hydrostatic pressure on the body (17).

Fluid shifts due to immersion appear to increase cardiac output and muscle blood flow, and reduce peripheral resistance increasing blood lactate recovery without a subject expending the energy required during active recovery (18).

Cold water immersion therapy is a modality that uses immersion of a body part in water with temperature below 15°C (19). Cold water immersion may have modulated inflammation and cellular stress after high-intensity and exhaustive exercise. There exists a long-standing belief that by reducing temperature and blood flow in skeletal muscle, cryotherapy such as icing or cold water immersion reduces the metabolic rate of and/or inflammation in tissues within and around the injured site in skeletal muscle (20). This supposedly protects neighboring cells against ischaemia after injury, which is thought to reduce the risk of secondary cell injury or death (21). Animal studies demonstrate the effectiveness of ice massage (22,23) or local infusion of cold saline (24,25) for reducing inflammation in muscle following injury. However, a little research have examined whether cold water immersion reduces inflammation after an exhaustive exercise. Leal Junior et al. (2011), for instance, reported that light emitting diode therapy has better potential than 5 min of cold water immersion for improving short-term post-exercise recovery. They found that creatine kinase (CK) activity and CRP level had no significant changes after the cold water immersion. We hypothesized that cold water immersion would more attenuate CRP level as the inflammatory marker after an exhaustive aerobic training compare to the passive recovery. Thus the purpose of present study was to examine the effect of cold water immersion on CRP levels after an exhaustive aerobic training.

## **2. Materials and methods**

### *Subjects*

20 male table tennis athletes, age ( $20.4 \pm 3.4$  year), height ( $174.4 \pm 4.5$  cm), weight ( $68.1 \pm 9.0$  kg) and BMI ( $22.3 \pm 2.6$  kg/m<sup>2</sup>) were participated in this study as the subjects. The subjects were given both verbal and written instructions outlining the experimental procedure, and written informed consent was obtained. The subjects were divided

into the passive recovery (n=10) or cold water immersion (n=10) groups. Participants were all familiar with exhaustive exercise training. All participants enrolled in the Bruce test protocol; then each group started its own recovery for 15 minutes.

#### *Intensive Exercise*

The Bruce test protocol was used as the exhaustive exercise training. This test includes 7 phases. This test is done on the treadmill and started with low intensity; every 3 minutes. The speed and the gradient (slope) of the device increased up to the level in which the subject could not perform the test anymore and became totally exhausted.

#### *Passive recovery*

The subjects in the passive recovery group were performed nothing out of the ordinary after the intensive exercise for 15 min.

#### *Cold Water Immersion*

The most popular cold water immersion temperature was between 10°C and 15°C (26). But in this study we selected 12°C for cold water immersion recovery. The participants of cold water immersion were immersed in the water up to Manubrium Sterni for 15 min.

#### *CRP measurement*

The CRP level was measured for all subjects in 3 phases of before the test, immediately after the test and immediately after the recovery strategies. CRP levels were determined in duplicate via an enzyme-linked immunosorbent assay (ELISA) kits (Diagnostics Biochem Canada, Inc). The intra and inter-assay coefficients of variation for hs-CRP were <5.7% and a sensitivity of 10 ng/ml.

#### *Statistical analysis*

All experimental and calculated values are presented as a mean  $\pm$  standard deviation. The repeated measures analysis of variance test is utilized to investigate the changes of variable means. The Bonferroni post hoc test is applied for the significant variation. The significance

level was set at  $P < 0.05$ . All data were analyzed using the SPSS version 17.0.

### 3. Results

The data on CRP concentration at baseline, after Bruce test and after 15 min recovery are presented in the figure 1. The results demonstrated that CRP level was increased significantly immediately after the Bruce test compared to the baseline and it was reduces significantly after the passive recovery ( $P < 0.05$ ). On the hand, as shown in the figure 1, CRP level was increased significantly immediately after the Bruce test compared to the baseline and it was reduces significantly after the 15 min cold water immersion ( $P < 0.05$ ).

No significant differences were observed between passive recovery and cold water immersion to reduce the CRP levels.

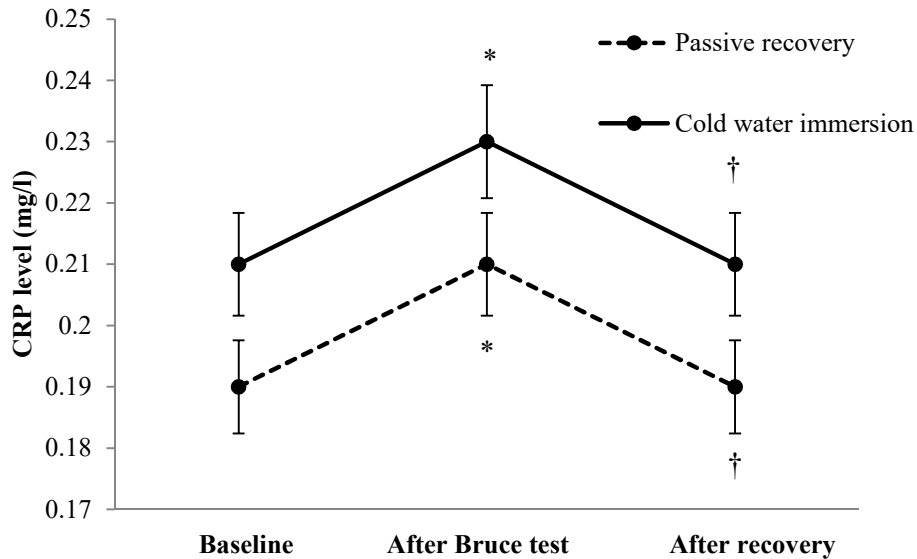


Fig 1. CRP level variations after passive recovery and cold water immersion

\*Significant difference with baseline ( $P < 0.05$ ).

† Significant difference with after Bruce test ( $P < 0.05$ ).

#### 4. Discussion

The effect of cold water immersion on CRP levels after an exhaustive aerobic training was examined in the present study. Exercise stimulated muscular inflammation and CRP level was increased after the exhaustive exercise training. Although CRP level was reduced significantly after passive recovery and cold water immersion, but contrary to our hypothesis, these responses did not differ substantially between cold water immersion and passive recovery. Previous studies indicated that regular application of cold water immersion attenuated long-term muscle adaptation compared with active recovery (27).

Animal studies have demonstrated that icing (28) or infusing cold saline (24,25) into injured muscle of rats reduces leucocyte rolling and adhesion, and neutrophil infiltration and activation. By contrast, another study found that cold water immersion did not reduce leucocyte counts in muscle of rats after exercise (29). Icing reduces and/or delays macrophage infiltration in rat muscle after muscle injury (22,23).

The effects of ice massage (30), cold water immersion (31,32), or exposure to  $-30^{\circ}\text{C}$  air (33) on systemic inflammatory responses to intense eccentric exercise or resistance exercise are variable and are relatively minor. In line with our results, Minett et al. (2014) also reported that cold water immersion reduces inflammation markers after intermittent-sprint exercise in the heat (34). However, Peake et al. (2017) noted that cold water immersion is no more effective than active recovery for minimizing the inflammatory and stress responses in muscle after resistance exercise (20). This difference could be related to difference in the temperature of cold water, exercise protocol that performed for induced inflammation and inflammatory markers that measured in these studies.

The Primary concept behind the cold water immersion is in reducing the painful feeling that depends on delayed onset muscle soreness that occurs with damage of muscle fibers and causes to decrease of muscle pain and increases the speed of recovery time (35). This kind of recovery causes the contraction of blood vessels, depletion of waste product such as lactate acid to the tissues that are not involved in pain, reduces the metabolic activity and delaying of physiological processes, reduces the

inflation and finally reduces the tissues' disability that these items are of benefits of cold water immersion. Cold water immersion may cause a reduction in pain through several possible mechanisms, namely the inhibition of nociceptors, reduction in metabolic enzyme activity, reduction in muscle spasms or an altered nerve conduction velocity (36,37). Moreover, Cold water immersion leads to the reduction of heart rate compare to the warm water immersion. Compared with the active recovery and passive recovery, cold-water immersion significantly lowered temperature after the recovery phase (38). Exposure to a cold-water immersion intervention can rapidly decrease muscle temperature and muscular force output (39). Water immersion methods cause's athletes to feel more relaxed and this issue can happen due to the floating force that is oppose of gravity and supports the part of body weight that is floating in water. This force causes lightness and weightlessness feeling. Also during water immersion neuromuscular responses reduce. As a result general comfort and a reduction in fatigue would be felt after exercise. Various methods of water immersion cause the complete comfort in muscles and a reduction in tension and anxiety (40).

## 5. Conclusion

According to results of this study, no significant differences are exist between the passive recovery and cold water immersion on reduction of exercise-induce inflammation; thus these two strategies are well for CRP reduction after intensive exercise. But according to the aforementioned benefits of cold water immersion specially the creating of mental vitality, it seems that this method could be a beneficial method for athletes as one of the suitable types of recovery; because methods of water immersion after activity due to natural muscles' massage, increasing of stretch and relaxation of body and mental, and reduction of neuromuscular fatigue is generally one of the best methods for professional athletes after exercises or competitions.

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**Conflict of interests:** No conflict of interests amongst authors.

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