

The Effect of Active and Passive Recovery on Creatine Kinase and C-reactive Protein after an Exercise Session in Football Players

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Abstract

Aims: One of the important issues in the context of exercise physiology is apply the best recovery methods completely after intense physical activities. Recovery methods will decrease the risk of muscle damage and subsequent inflammation. The aim of this study is to investigate the recovery procedures on changes of creatine kinase (CK) and C-reactive protein (CRP) after an exercise session simulated in professional football players. **Methods:** Thirty Iran's Azadegan League football players were participated in this research (age: 22.4 ± 2.38 , height: 179.1 ± 2.63 cm, weight: 68.5 ± 4.82 kg, body mass index: 21.5 ± 2.10 kg/m²). After exercise protocol, simulation team randomly divided the participants into three groups ($n = 10$) under an active recovery on land, floating in the cold water (10°C), and passive recovery for 12 min. The levels of serum CK and CRP were collected immediately, 24 h, and 48 h after the exercise protocol. **Findings:** The results showed a significant decrease in CK and CRP after training in cold-water immersion method comparing to the other methods ($P < 0.05$). In addition, the level of CRP was significantly less than passive recovery 48 h postexercise recovery ($P < 0.05$). **Conclusion:** The finding of this study shows that if recovery in cold water was used immediately after exercise, much better results are obtained in future periods. This means that immersion method in cold water probably leads to decreased signs of muscle soreness and inflammatory responses in male football players.

Keywords: Cold-water immersion, inflammatory responses, muscle damage, muscle enzymes, muscle soreness, recovery methods

INTRODUCTION

There is a difference in the field of sport physiology between health-related (physical fitness) and skill-related (motor fitness) indicators. The professionalization of sports has caused athletes to deprioritize its health aspects. Overwhelming sports competitions has increased the physiological and psychological injuries and has caused more stress among athletes.^[1,2] One of the most important factors is the lack of proper recovery after training sessions and competition. To address this, researchers have come up with various solutions. The most common of these recoveries is the use of passive, active, or water immersion techniques. However, there is still room to discuss the most efficient approach.^[3-6] Passive recovery refers to the use of stillness and inactivity exercises during the cool down period. By contrast, active recovery means being active in a way that promotes recovery rather than intensity. In fact, one of the proper recovery mechanisms is the reduction

of inflammation and postexercise muscle damage that will prepare the athlete for future games. The most important of these muscle damage and inflammatory biomarkers is the measurement of the concentration of creatine kinase (CK) and C-reactive protein (CRP).^[7,8]

CK also known as creatine phosphokinase or phospho-CK is an enzyme gene expression by various tissues and cell types. CK activity is greatest in muscle fibers.^[9] The determination of CK concentration is a proven tool in the investigation of skeletal muscle disease.^[10] Increased levels of CK are one of the factor of certified muscle damage.^[11]

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The CRP is a protein found in blood plasma; its level rises in response to inflammation. Enhancement of the concentration of these enzymes plays an important role in determining muscle damage.^[12,13] Long-term contractions stimulate the inflammatory response. At the time of injury, phagocytic cells attack the damaged tissues, then, leukocytes activate, and cytokine secretion is increased.^[14]

Meanwhile, football players are more vulnerable to physical and psychological stress as well as more tournaments.^[15,16] Football is an alternating sport with maximal and submaximal activities for 90 min and often even longer. The amount of running depends on player's position and their level of endurance or technical competence. Football requires high energy for very fast running as well as employing several techniques including dribbling, shooting – by feet or head, tackles, and shuttle run.^[11,16,17] On the other hand, studies have not been done in this field (exercise and recovery methods) of comparison CK levels and CRP in football players. In addition, few studies have been done in professional athletes, and there is the lack of integrated information on this topic. Therefore, this study was investigated the effect of active recovery and immersion in cold water on CK levels and CRP at football players after simulated team-sport exercise.

MATERIALS AND METHODS

The aim of this study is to evaluate and compare the level of CK and CRP between three recovery methods: passive, active, and cold-water immersion. For this purpose, professional male Azadegan League football players (the second-highest division league in the Iranian football league) participated in this study and provided written consent voluntarily. Each player was required to fit within a specified height, body mass, and weight range [Table 1].

All players were free of injury and illness at the time of testing as well as being healthy during studies games. The participating players were asked to have their usual diet and avoid any vigorous exercise for at least 72 h before implementation of the exercise program. The participants were randomly assigned to three groups of (1) active recovery ($n = 10$) includes: jogging, shuttle run, and stretching, (2) passive recovery ($n = 10$) includes sitting and lying down, and (3) flotation in cold water ($n = 10$) and sitting in water with a temperature of 10°C. The experimental protocol was approved by the

Research Ethics Committee at the Islamic Azad University, Mahallat Branch, Arak, Iran.

The players had complete rest for 15 min before sample collection. Blood samples were taken in three times at immediately, 24 h, and 48 h after exercise protocol. The ambient temperature was about 22°C. All measurements were performed in the same time interval. After the exercise, players were carried out physical activity including simulated football exercise. The special exercise consisted of a 15 min standard walking, dribbling the ball through the obstacles, running back, running fast, and shuttle run along four straight lines with 50 m apart. After a 5-min break, players carried out another 20-m shuttle run. Players' levels of CK and CRP were measured at formerly mentioned intervals (12 min postrecovery) by enzyme-linked immunosorbent assay method and using the Pars Azmoon commercial kit (Pars Azmoon kit, Pars Azmoon Co., Tehran, Iran), according to manufacturer's instructions.

Data are expressed as mean and standard deviation. Normalized distribution of data was determined using the Kolmogorov–Smirnov test. To analyze the data and investigate the difference of variables measured across the studied groups, two-way ANOVA was used to investigate the obtained results, and it was followed by least significant difference *post hoc* test to examine the independent and interactive effect of the applied variables. All statistical analysis was performed using SPSS 18 computer software (PASW Statistics 18, IBM SPSS Statistics) and the significance level was $P < 0.05$ considered.

RESULTS

The level of serum CK and CRP concentration was increased 24 h after exercise compared to the one of immediately after exercise among groups [Figures 1 and 2]. There was no significant difference immediately after exercise among groups. According to the results, the average level of CK 24 h posttraining in passive recovery method was significantly higher than the recovery with cold-water recovery method ($P = 0.032$). However, levels of serum in both active and passive recovery show no major difference. It was also observed that level of CK serum in cold-water recovery method 48 h after exercise is significantly less than two other recovery methods ($P < 0.05$). This difference was not significant between the two methods of active and passive recovery.

The average value of CRP 24 h after exercise in passive recovery is less than active recovery. However, the difference was not statistically significant. The average value of CRP 24 h postexercise, was significantly more than cold-water recovery ($P = 0.023$). The results showed that level of CRP 48 h after exercise in cold-water recovery was significantly lower than other two methods ($P < 0.05$). The CRP level in active recovery was significantly lower than in passive recovery ($P < 0.05$).

DISCUSSION

Muscle soreness is reflecting muscle damage in the process of physiological adaptation muscle with intense training.

Table 1: Physical characteristics of players in three groups

Group	Age	Height	Weight	BMI	P
Passive recovery	22.4±2.38	179.1±2.63	67.5±3.82	22.5±1.10	<0.05
Active recovery	21.4±3.18	177.3±3.23	68.5±4.72	21.8±2.10	<0.05
Cold-water recovery	21.8±2.25	176.8±4.83	68.8±3.88	22.2±1.8	<0.05

BMI: Body mass index

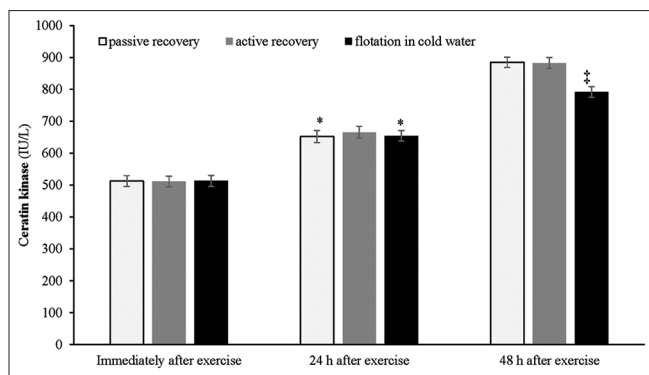


Figure 1: The changes of creatine kinase among different recovery methods. *The significant difference among cold-water recovery method and two other recovery methods. *The significant difference between cold-water recovery method and passive recovery method

One of the mechanical factors of muscle soreness may cause sarcomere damage in muscular structure.^[18] Delayed muscle soreness leads to rupture sarcomere, which relates with increased levels of CK. Muscle soreness due to signs such as discomfort, pain, and loss of physical function occurs. The pain of muscle soreness typically appears 12–24 h after the exercise, which may continue for 2–5 days and is related to the increased levels of CK.^[19] Fatigue in the muscle fibers has created reduction in membrane resistance, which increases the release of calcium ions inside the membrane tissue damage by decomposed Pages Z, followed by the disappearance of the sarcomere. High-intensity physical activities stimulate the inflammatory responses in muscle.

Recovery methods are vital parts after any training programs. Principled and correct recovery methods can decrease substances, which produced by metabolism and lead to improved physical and mental condition of athletes. Coaches and athletes should be noted that psychological and physiological recovery could well maintain the athlete's performance for the next competitions.^[20]

Many methods have been proposed for the recovery of athletes, which includes of stretching movements, massage, ice compresses, anti-inflammatory drugs, antioxidants, immersion in cold water, immersion in contrast water, immersion in warm water, and electrical stimulation recovery. Immersion in cold water and conflicting water methods have been reported as useful recovery methods that lead to the excretion of lactic acid and CK after a rugby match and intense aerobic exercise.^[21-23]

Immersion in cold water causes the reduction of cell permeability through vasoconstriction and contributes to reduction of inflammatory response, muscle damage, edema, and feeling pain.^[6] In contrast, some studies reported that immersion in cold water has no effect. For example, Pournot *et al.* investigated the effect of different methods of recovery in water on CK.^[4] Recovery methods included immersion in hot water, immersion in cold water, immersion in contrast water, and passive recovery. Their results suggest that there is no significant difference on the level of CK serum in

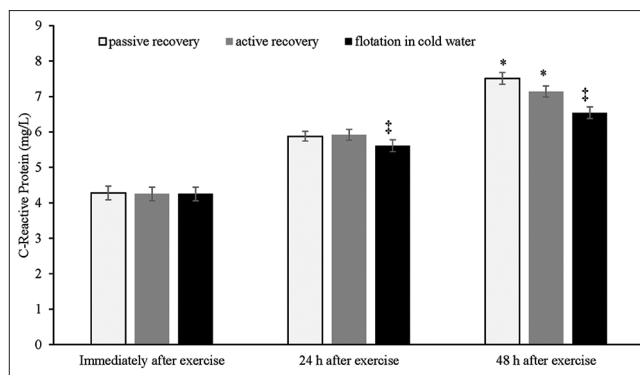


Figure 2: The changes of C-reactive protein among different recovery methods. †The significant difference among cold-water recovery method and two other recovery methods. *The significant difference between active recovery method and passive recovery method

the cold-water immersion with the other methods. Another recovery technique, which used after exercise, is active recovery. Furthermore, in active recovery, muscle glycogen content remains almost constant.^[24]

In the present study, extreme acute exercise was lead to significant increase in CK level. The results show that average level of CK serum 24 h after exercise in active recovery method was less than passive recovery method, but this difference is not significant. The average level of CK serum in cold-water recovery group was less than active recovery, but the difference was not statistically significant. However, there was a significant difference between the immersions and passive recovery methods [Figure 1]. As a result, immersion recovery in cold water turns to demonstrate a positive impact on the recovery CK levels 24-h football posttraining. The major finding of this investigation was level of CK serum, which was significantly different among groups 48 h after exercise. It can be seen that the level of CK serum, 48 h after exercise, is significantly lower in cold-water recovery method than the other two methods ($P < 0.05$). The level of serum in active recovery method was lower than passive recovery, with no significant differences ($P = 0.753$). These results are matches with earlier studies.^[3,21,25]

Gill *et al.* investigated the effect of different methods of recovery on plasma CK activity in 23 elite rugby players postmatch.^[21] The results showed that immersion in cold water, compared to passive recovery, reduces the activity of CK significantly. It is reported that reduction of CK depends on the temperature of cold water. Immersion in cold water due to created vasoconstriction prevents inflammation leading to a decrease in CK.^[4] Through the rapid restoration of glycogen, active recovery quick returns to resting state.^[20] Intensity of the recovery is of the most important factors that should be controlled according to the adverse effect of recovery caused by accumulation of substances produced through metabolism.^[26]

Demirhan *et al.* investigated the effect of immersion in cold water and ice massage after exercise in elite wrestlers.^[11] They reported that there was no significant difference between the

effects of the two methods on the level of CK in athletes. This is because the stimulation of the enzyme CK depends on intensity and duration of muscle contraction.^[18] May be one of the reasons for the lack difference between the studies methods may be due to the exercise protocol.

Pantoja *et al.* studied the effect of floatation in water on CK levels on 38 male bodybuilders after strength training.^[27] The results showed a significant reduction in levels of CK serum at 24 and 72 h postimmersion in cold water compared to passive recovery, which is consistent with the present study. The agreement of these studies could be attributed to using the same timeline for blood collection. The time of appearance and clearance of plasma CK depends on the type, severity, and duration of exercise. The peak serum CK is 8 h after intense exercise. Specifically after a long-training period, CK activity is increased at 24 h postexercise. Strenuous physical activity, such as football training twice a day practice, is leading to increase during the 4th day, and CK levels remain high between 4 and 10 days. In present study, like previous studies, CK levels peaked at 48 h posttraining. In a previous research, Russell *et al.* (2003) used immersion in cold water to Decrease neurological symptoms of the muscles as well as biomechanical muscle injury in training models with similar demands and exercise which was in agreement with our results.^[28] There is a general agreement on the use of immersion in cold water to reduce soreness, and fatigue understands there practicing.^[3] Mechanisms responsible for the reduction of injury, and muscle soreness after applying immersion in cold water gets involved not yet entirely clear. However, one of the proposed mechanisms is that the immersion of cold-water method reduces the release of muscle enzymes in the lymphatic system. It is the issue that reduces the release of CK after immersion in cold water may be due to the ability to reduce the permeability of blood vessels.^[29]

In addition, in the present study, the significant difference between CRP levels at 24 h postexercise recovery methods was observed to be significant. A significant reduction occurs for CRP in cold-water recovery method too. Therefore, we can say that CRP levels 24 h after exercise in cold-water recovery are lower than the other two methods. The CRP is an acute phase protein of hepatic origin that increases following interleukin-6 secretion by macrophages and T cells. Ingram *et al.* were compared the effect of immersion in contrast water (10°C and 40°C) and cold water (10°C) and passive recovery on levels of CRP serum after a simulated team exercise.^[25] The immersion in cold water compared to the immersion in contrast water after 1 and 20 h showed a significant decrease. Ingram *et al.*'s results are consistent with the findings of the present study that the reason could be factors such as same intensity, duration, and type of player's activity.^[25]

Dabidi Roshan *et al.* looked into the effects of recovery in water versus land on changing the CRP after a period of intermittent fast swimming. There was no significant difference for CRP levels between two methods of recovery, which is not consistent

with our findings.^[8] One reason for the lack of methodological differences in Dabidi Roshan *et al.*'s study was lack of necessary pressure on CK serum level. The values of these variables in peoples, who are performing a minimal regular physical activity and style, are similar to those people who are continuously active.^[30] A separate review of each exercise in studies showed that CRP value in nonathletes was more than professional and committed athletes. This may be due to the exercise and adaptation to exercise and the inhibitory effect of exercise on CRP.^[8] It is known that a high-intensity exercise triggers stronger inflammatory responses in younger people.^[31]

According to the results of the present research, it can be observed that CRP at 48 h after exercise by cold-water recovery was significantly less than the other two methods. In addition, the level of CRP in active recovery is also significantly lower than passive recovery [Figure 2]. CRP is the most acute phase proteins in response to numerous injuries including surgery, tissue damage, inflammation, and sports, which released from liver. Some studies have reported an inverse relationship between CRP levels and cardiorespiratory fitness.^[7] It is believed that active recovery through rapid restoration of glycogen leads to a rapid return to the initial stages. In case of lack of control in the intensity of activities in active recovery method, the accumulation of substances produced by metabolism occurs and has an adverse effect on recovery.^[32] In addition, immersion in water creates hydrostatic pressure on the body and blood moves from the lower region to the pectoral region during floatation. The blood flow leads to speedier clearance of substances produced by metabolism.^[32] Hence, immersion in cold water as a suitable method to reduce edema and inflammatory responses caused by tissue damage is recommended. It can help reducing inflammation after an intense and traumatic exercise.

CONCLUSION

Methods of immersion in water after physical activity – because of naturally massaging the muscles – increase traction and mental relaxation, reduce fatigue and muscle soreness, and are highly recommended for athletes after exercise. Different recovery methods use water because of a faster return to physical and mental condition to the initial state compared to nonwater methods.^[33] Researchers have assumed using of cold-water recovery after exercise, or competition can reduce the inflammatory response and muscle damage by reducing permeability of the blood and lymph vessels. Probably, this reduces the release of inflammatory biomarkers of muscles. This method also reduces nerve impulse conduction velocity in surface tissue by reducing the activity rate of muscle spindle afferents and response reflection; in general, it reduced spasms and muscle pain.

The future researches are needed to explore the advantages and disadvantages of cold-water recovery on the muscle damage and inflammation due to intense physical activity. Further research with physiological valid values for team

sports will further elaborate mechanisms of muscle damage, inflammation, and the effects of immersion in water on these variables.

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Conflicts of interest

There are no conflicts of interest.

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