



Experience of cold-water immersion on recovery efficiency after soccer match **Expérience d'immersion en eau froide sur l'efficacité de la récupération après un match de football**

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RÉSUMÉ

Introduction : l'immersion en eau froide est l'une des techniques de récupération et de rééducation les plus courantes chez les athlètes. Cependant, plusieurs facteurs tels que le choc induit par l'eau froide peuvent affecter l'efficacité de cette technique.

Objectif: Le but de cette étude était d'étudier l'effet de 4 semaines d'habituation à l'eau froide sur l'efficacité de la technique de récupération CWI sur les dommages musculaires et les indices fonctionnels des jeunes footballeurs.

Méthodes: Vingt jeunes hommes sans expérience préalable du CWI ont participé à cette étude. La puissance de sortie et le RSADEC des sujets ont été mesurés. Les sujets ont ensuite effectué un test de football simulé et, après avoir recueilli des échantillons de sang, ont été immédiatement immergés dans de l'eau à 15° C pendant 15 minutes. Vingt-quatre heures plus tard, les prélèvements sanguins et les tests fonctionnels ont été répétés. Les sujets ont ensuite été divisés au hasard en deux groupes d'exercice avec récupération CWI et exercice avec récupération passive. Après quatre semaines, le prélèvement sanguin et les tests de performance se répètent comme le pré-test.

Résultats: Le CWI n'a eu aucun effet significatif sur les taux sériques d'AST et de LDH avant et après 4 semaines de CWI ($P > 0,05$). De plus, il n'y avait pas de différence significative entre la puissance de sortie et le RSADEC après CWI avant et après l'accoutumance à l'eau froide ($P > 0,05$).

Conclusions: Il semble que l'expérience de récupération par immersion en eau froide n'ait aucun effet sur l'efficacité de cette méthode. Par conséquent, les entraîneurs de football et les athlètes devraient réfléchir davantage à l'utilisation de cette méthode de récupération.

Mot clés : récupération - exercice épuisé – performance

SUMMARY

Background: immersion in cold-water is one of the most common recovery and rehabilitation techniques among athletes. However, several factors such as shocking induced by cold water can affect the effectiveness of this technique.

Aim: The aim of this study was to investigate the effect of 4 weeks cold water habituation on the effectiveness of CWI recovery technique on muscle damage and function indices of young soccer players.

Methods: Twenty young men with no previous experience of CWI participated in this study. Output power and RSADEC of subjects were measured. The subjects then performed a simulated soccer test and, after collecting blood samples, were immediately immersed in 15 ° C water for 15 minutes. Twenty-four hours later blood sampling and functional tests were repeated. Subjects then were divided randomly into two groups of exercise with CWI recovery and exercise with passive recovery. After four weeks, the blood sampling and performance tests repeated like the pre-test.

Results: The CWI had no significant effect on serum levels of AST and LDH before and after 4 weeks of CWI ($P > 0.05$). Also, there was no significant difference in power output and RSADEC after CWI before and after cold water habituation ($P > 0.05$).

Conclusions: It seems that the experience of recovering by immersion in cold-water has no effect on the effectiveness of this method. Therefore, soccer coaches and athletes should think more about using this recovery method.

Keywords: recovery- exhausted exercise- performance

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INTRODUCTION

Nowadays, immersion in cold water is one of the popular ways of recovery among athletes specially team sports athletes. CWI is one of the most popular methods among athletes, which is done mainly to reduce muscle damage caused by sports activities and accelerate the athlete's recovery. In this method, all or part of the person's body is placed in cold water. Although there is no specific protocol for performing immersion in cold water, a water temperature of 15° C for at least 10 minutes has been suggested (1). In this regard, immersion in 10° C water for 10 minutes after a soccer match significantly decreased muscle soreness in compared to the control group of young male soccer player. Also, immersion in 15° C water for 14 minutes decreased muscle soreness indices compared to the control group after a session of strength training (2, 3).

Benefits of CWI in reducing post-exercise fatigue perception has been reported too (4). However, not all studies observed benefits of CWI recovery after exercise (2, 5). Some studies have even argued the CWI could be harmful for performance and in some physiological markers such as endothelial injury index while the control group in these studies were better conditions than the CWI group (6) (7). In another study, the efficacy of CWI (14° C for 20 minutes) versus warm water immersion (39 ° C for 20 minutes) was investigated on load of training after 5 days of heat training in. The result showed that CWI can have negative effect on load of training (8).

Although several factors, such as water temperature, duration and frequency of immersion in water can affect the effectiveness of CWI, however, individuals' response to cold shock of immersion in cold water may also be considered as a negative factor (9). In other words, the previous experience of CWI by athlete may decreased negative effects of shock of immersion and consequently increase the effectiveness of CWI as a recovery technique. In support of this idea, it has been reported that regular immersion of one leg for 15 minutes at 10 ° C for 4 weeks lead to microvascular adaptations in compared with other leg which was as control (10).

Since there is little information about cold water immersion habituation on the effectiveness of CWI recovery, the aim of this study was to evaluate the muscle damage and performance indices of young soccer players after four weeks of cold-water habituation.

METHODS

Participants

This quasi-experimental study was conducted with two groups of immersion in cold water (CWI) and passive recovery (C) with pre-posttest design. Twenty young men with 18±1-year age and no previous experience of CWI participated in this study. Information on the properties of anthropometric variables is shown in Table 1. Before the study, written informed consent was obtained from subjects and the study was approved by the Ethical Committee on Human Research of the Ferdowsi University of Mashhad, Iran, and was conducted according to the Declaration of Helsinki and its later amendments.

The inclusion criteria were included the experience of attending at least 2 years of professional soccer training, not consuming sports, and pharmaceutical supplements during the research, and not participating in any activity other than the prescribed training program.

The exclusion criteria were non-regular participation in the exercises for more than 3 consecutive sessions and a total of 5 sessions during the research and any injuries or physical problems that made it difficult to perform the exercises.

Table 1. Individual, anthropometric, and physiological characteristics of the subjects in two groups. All values were reported by Mean±SD

Variable Groups	Age (year)	High (cm)	Weight (kg)	BMI (kg/m ²)	Vo ₂ max (ml. kg ⁻¹ .min ⁻¹)
CWI	18±1	173.90±2.21	63±1.40	20.84±0.37	50.27±0.88
C	18±1	171.10±2.26	58.40±2.28	20.02±0.54	49.16±0.60

Instrumentation

To measure physical performance of participants, stopwatch (Japan, Q and Q HS43 Sport Stopwatch) and measuring tape (Germany, seca 201) were applied. Biochemical analysis for LDH and AST (PARS AZMON kit –Iran) serum levels was assessed by using photometric method.

Tasks

CWI and passive recovery protocols:

The CWI group was immersed in cold water naked (with a sports shorts) in 15 ° C water for 15 minutes until chest height immediately after training (11). The passive recovery (C) group performed the stretching exercises immediately after training for 10 minutes for the quadriceps, twins, and hamstring muscles, respectively.

The exhausting exercise protocol:

The exhausting exercise in this study was a simulated soccer match involving agility, walking, jogging, and running at different intensities. In this test, subjects first warmed up for 15 minutes. The warm-up included running, stretching, and jumping. Subjects then performed the LIST. Briefly, the test consisted of five 15-minute sets that separated the first three sets by a 3-minute rest from the next two sets. In this test every 15 minutes simulated soccer training subjects consisted of 3 repetitions of 20 m jogging, one 20 m running, 4 seconds rest, 3 repetitions of 20 m jogging with 55% VO₂max and 3 repetitions of 20 m sprinting with 95% VO₂max (subjects' running speed was controlled based on each subject's shuttle run test). Subjects then ran to fatigue to ensure proper exercise pressure, such that they ran the distance between two 20-m lines alternately with 55 and 95% VO₂max until they failed to reach the line twice at the specified time. The exhausting exercise lasted approximately 90 minutes (12) (Figure 1). The shuttle run test was used to estimate the VO₂max (13).

RSA_{Dec} determination:

RSA test were used for this purpose. The test consisted of 15 times running the 40-meter route, with subjects

running at maximum speed. Subjects rested 30 seconds after each 40-m run. At the end of the test, the percentage of performance reduction was calculated based on the following formula which *s* is the time of each sprint and *s_{best}* is the best record among 15 repetitions (14).

$$RSA_{Dec} = \left[\frac{s_1 + s_2 + s_3 + \dots + s_{final}}{s_{best} \times \text{number of sprints}} - 1 \right] \times 100$$

Output power:

Sargent vertical jump test were used to estimate power. The test was done by placing the subject next to the wall. Then he raised his hand from the side to the highest point, the touch point recorded for him. The subject then jumped to the highest point after bending the knees to 90 degrees. The distance between the second and the first point was recorded as the subject's jump distance. Each subject performed the test three times and the best record was recorded. The subject was also allowed to take a 2-minute pass between each attempt. The output power was then calculated using the following formula in watts (15).

$$(W) = 41.4 \times VJ \text{ (cm)} + 31.2 \times \text{mass (kg)} - 13.9 \times \text{height (cm)} + 431$$

Measurement of blood biomarkers:

Blood samples were collected by an expert in laboratory science from the left arm (in sitting position) immediately after the exhaustive exercise session and 24 hours after the recovery protocol before and after 4 weeks. Blood samples were then centrifuged at 3000 rpm for 20 minutes and then stored at -80 °. Blood samples were collected by an expert in laboratory science from the left arm (in sitting position) immediately after the exhaustive exercise session and 24 hours after the recovery protocol before



Figure 1. An overview of the exhausting exercise protocol. LIST: Loughborough Intermittent Shuttle test.

and after 4 weeks. Blood samples were then centrifuged at 3000 rpm for 20 minutes and then stored at -80° . The blood serum was used to determine LDH and AST.

Procedures

In the first session, Familiar with the procedure and signed informed consent form before the study, the subjects' initial information including anthropometric characteristics and 3 days food recall were collected. In the second session, the VO_2 max was estimated. In the third session (24 h after the second session), the functional tests in order to estimation the RSA_{Dec} and power output were carried out. In the fourth session (48 hours after the third session), participants performed a simulated soccer game as an exhausting exercise which was followed by blood sampling and the CWI recovery protocole. At the fifth session (after 24 hours of the fourth session) blood samples were collected and the functional tests were repeated. Subjects then were randomly divided into two groups of cold-water immersion recovery (CWI group, N=10) and passive recovery (C group, N=10). After four weeks, blood sampling and functional tests before and after stimulated soccer game were repeated like the pre-test (Figure 2). All subjects participated in a soccer training program for 4 weeks and 5 sessions per week. The soccer training program was included 15 minutes of warm-up, 15 minutes of agility and speed, 50 minutes of specialized soccer (tactical and technical) training and 10 minutes of cooling for both groups. The C group performed 10 minutes of stretching exercise after each session, whereas the CWI group performed 2 sessions per week the cold-water immersion protocol and the remaining three sessions were similar with C group.

Statistical Analysis

Independent variable of this study was 4 weeks of CWI applying during condition phase of young soccer players. After collecting and entering the data in SPSS software version 22, the raw data were analyzed. Descriptive statistics were used to calculate the central tendency and dispersion indices of the variables. After confirming the normality of the data distribution by Shapirovilk test and analysis of variance homogeneity by Levon's test, repeated measure ANOVA and Bonferroni post hoc test were used to determine intra- and intergroup changes of serum levels of LDH and AST immediately and 24 hours and performance tests per and post of exehustive task, befor and after of 4 weeks of study. A significance level of $p \leq 0.05$ were considered.

RESULTS

The results showed that before and after of four weeks of cold-water habituation, there was no significant difference foe LDH and AST serum levels of young soccer players after CWI recovery ($P > 0.05$).

Based on the results of this study, there were no significant difference before and after four weeks of cold-water habituation on the output power and RSA_{Dec} of young soccer players after CWI recovery ($P > 0.05$).

DISCUSSION

The purpose of this study was to investigate the effect of four weeks of cold-water habituation on the effectiveness of

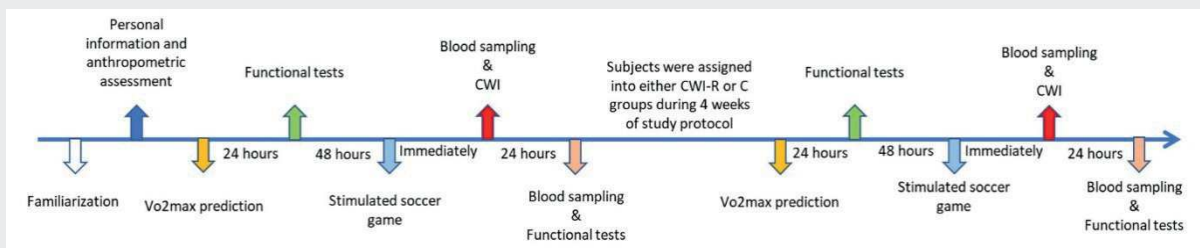


Figure 2. Schematic view of the research design.

CWI on muscle damage and performance indices of young soccer players. The results of our study demonstrated that previous experience of CWI before a competition did not improve efficacy of CWI recovery strategy after match. Although several factors can affect recovery efficiency by CWI, including the characteristics of the recovery protocol (water temperature, duration of immersion in water, frequency of immersion), the intensity and physiological nature of the activity or competition performed, and the characteristics of athletes (age, gender, fitness), however, few studies have examined the effect of adaptation and previous experience of immersion in cold water on the efficiency of CWI recovery. Past studies have reported improvements in the immune system, decreased stress and inflammatory responses, increased antioxidant concentrations, increased heat shock proteins, and improved response to exercise in hypoxic conditions in adapted versus non-adapted subjects to cold water (16-20).

The results of the present study showed that there was no significant difference in LDH serum levels between groups at all four measurement times (immediately and after 24 h of the exhaustive test before and after four weeks) (Table 2). In a study of martial athletes (Jujitsu), LDH levels were lower after 24 hours in the CWI group than in the control group. In this study, 8 trained men were immersed immediately in the 4-minute repetition at 6° C immediately after training. Between every four minutes, subjects rested one minute out of the water (21). In contrast, another study examined the effect of CWI after rugby competition on muscle damage indices. In this study, 20 trained rugby men were divided into two groups: CWI and inactive recovery, and CWI group immersed in cold water for 10 minutes in 15° C. The results showed that there was no significant difference between the control and CWI groups at LDH, CK and AST levels after 24 h (22). It seems that the peak activity in serum LDH observes 8h after exercise, future studies should consider serial blood sampling from immediate to 48 h after CWI recovery (23).

Table 2. Changes in values of LDH and AST before and after 4 weeks of CWI habituation

Variable	group	Pre-test mean±SD		Post-test mean±SD		Between group comparison	
		Immediately after recovery	24 h after recovery	Immediately after recovery	24 h after recovery	F	P
LDH (U/L)	CWI	300.80±28.44	352.10±57.62	298.20±61.18	345.30±65.99	0.958	0.103
	C	313.90±38.39	365.50±65.52	324.30±80.19	370.40±64		
AST (U/L)	CWI	27.70±7.18	27.00±8.57	26.50±4.17	25.22±5.20	0.528	0.634
	C	25.00±3.59	26.20±5.75	22.66±2.69	24.50±1.06		

* Statistically significant difference; LDH- Lactate dehydrogenase; AST- aspartate aminotransferase; CWI- Cold water immersion; C- control

Table 3. Changes in values of power and RSADec before and after 4 weeks of CWI habituation

Variable	group	Pre-test mean±SD		Post-test mean±SD		Between groups	
		Before recovery	After recovery	Before recovery	After recovery	F	P
Power (w)	CWI	1611.87±128.75	1680.70±266.15	1739.70±383.01	1809.20±349.86	0.019	0.996
	C	1479.55±232.57	1605.87±165.40	1570.20±289.21	1542.22±222.30		
RSADec (%)	CWI	7.90±2.81	6.76±1.33	4.30±1.35	5.51±1.41	0.309	0.819
	C	7.03±2.69	6.90±1.49	4.30±1.35	5.46±1.53		

* Statistically significant difference; RSADec- Percent of decrease of repeated sprint ability; CWI- Cold water immersion; C- contro

In general, the proposed mechanism of the effect of cold-water immersion on the reduction of muscle damage has been suggested that after 24 hours of intense training, the damaged muscles will become painful and swollen. In addition, increased blood flow to the muscle causes swelling of the muscle tissue. The nerves receive these unusual messages and then send the pain message to the brain. The result of all these complex processes is ultimately the release of muscle damage markers into the bloodstream (24). Immersion in cold water by reducing muscle blood flow can prevent or reduce muscle swelling after training and send pain signals to the brain. On the other hand, immersion in cold water reduces permeability of the vascular wall and prevents cell swelling, which results in both mechanisms, a decrease in the transmission of pain messages, and consequently a decrease in the diffusion of muscle damage markers into the bloodstream (4, 25). However, the rate of release of these enzymes in trained individuals appears to be different from untreated individuals (26).

According to the results of the present study, there was a no significant difference in AST serum level between groups at both stages before and after 4 weeks immediately and 24 hours after CWI (Table 2). Similarly, Takadi et al., Who investigated the effect of CWI following a simulated rugby game, reported no effect of cold water immersion on serum levels of AST (22).

Increased levels of AST circulation during intense and high impact activities appear to be unaffected by recovery techniques, such as CWI, which are generally performed after the end of training or competition.

The results of the present study showed that there was no significant difference between the groups in both stages before and after 4 weeks in RSA_{Dec} (Table 3). The ability to repeat sprints is one of the key factors in soccer (27). The results of several studies that examined the effect of CWI recovery on the ability to repeat sprints were consistent with our results (28-31)..

One of the possible causes of the lack of effect of CWI on the ability to repeat sprints can be that immersion in cold water probably has no effect on muscle lactate concentration, and by lowering blood and muscle pH, the enzymes involved in the anaerobic glycolysis pathway is impaired, which results in slower energy production and reduced

performance(32) . Antonio et al. In their study showed that the effects of immersion in cold water were more significant 24 and 48 hours after recovery (2). Although in the present study, habituation to cold water immersion did not improve the effectiveness of the recovery technique of CWI, future studies appear to evaluate the effects of CWI recovery over different time periods.

Limitations

This research has limitations. Nutritional, body water status and sleep quality and quantity of participants of this study did not evaluated during the study. All of this factor can affect the rate of muscle damage and performanc. The participants were asked to avoid from intense activity 24 hours prior to the testing sessions. However, we cannot confirm whether they complied. The subjects were not blinded during the data collection on whether they were receiving CWI or passive recovery.

According to the findings of the present study, it seems that cold water habituation does not improve the potential benefits of CWI recover in young soccer players following maximal activity. In fact, applying CWI recovery does not have a significant effect on the effectiveness of CWI recovery on muscle damage and function after a stimulated match in young soccer players.

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