

## **Effects of tow protocol cold water immersion on the post match recovery and physical performance in youth handball players**

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### **Abstract**

The purpose of this study is to compare two cold water immersion (CWI) protocols, continuous and fractionated, to optimize the recovery of Handball players after on recovery from exercise resulting in exercise-induced muscle damage.

Ten male Handball players (age:  $15 \pm 1.4$  years, mass index:  $67.2 \pm 5.1$  kg, height:  $176.6 \pm 7.30$ ) voluntarily participated in the study. After three 90-minute training sessions (heart rate  $160 \pm 15.81$ ,  $156 \pm 5.53$  and  $156 \pm 12.24$  bpm) per week, participants were divided into 03 groups. The first experimental group (GE1) in continuous immersion (CWIC) of (12 minutes,  $12 \pm 0.4$  ° C), a second experimental group (GE2) in fractional immersion (CWIF) of (4 x 2 min at  $12 \pm 0.4$  ° C + 1 min out of water) and a control group (GC) in passive recovery. Body mass indices (BMI), countermovement jump and muscle pain were measured. The results concerning the percentage differences in the variation of the CMJ occurred respectively at 24h ( $Z = 12.62$ ,  $p = 0.004$ ) and 48h ( $Z = 16.22$ ,  $p < 0.001$ ) compared to the control group. In addition, the results for muscle volume did not report any significant interaction ( $F(5.64) = 3.42$ ,  $p = 0.078$ ). The results of both protocols showed their effectiveness in reducing pain intensity by 24 and 48 hours after intense training ( $F(3.54) = 2.91$ ,  $p = 0.016$ ,  $p_2 = 0.24$ ).

In conclusion, continuous and fractionated cold water immersion is beneficial for neuromuscular recovery 24 hours after intense exercise. The results also demonstrate a rapid recovery of handball players from their physical potential required in high level competitions.

**Keywords:** Cold water immersion recovery handball

## Introduction

There is Cold water immersion (CWI) is a popular form of cry therapy and considered one of the most effective for reducing tissue temperature and sustained cooling after removal (Vieira et al., 2016) and speed up the recovery process (Calleja-González et al., 2016; G., Halson, & Dawson, 2013).

Different approaches to these methods (G. et al., 2013; Hohenauer, Taeymans, Baeyens, Clarys, & Clijisen, 2015), as well as the results (Christensen et al., 2016; Hohenauer et al., 2015; Leeder, Gissane, van Someren, Gregson, & Howatson, 2012; Sanchez-Ureña, Barrantes-Brais, Ureña-Bonilla, Calleja-González, & Ostojic, 2015) have shown a beneficial effect of these techniques in recovery. In contrast, other studies have reported no significant effect on recovery (Higgins, Greene, & Baker, 2017; Murray & Cardinale, 2015). More specifically, experimental studies indicate that CWI generates a series of physiological changes including, the reduction of core body temperature (Peiffer, Abbiss, Watson, Nosaka, & Laursen, 2009; Yanagisawa, Homma, Okuwaki, Shimao, & Takahashi, 2007), acute inflammation (Vaile, Gill, & Blazeovich, 2007), muscle spasms, and pain sensations (Washington, Gibson, & Helme, 2000), localized edema (Vaile et al., 2007), as well as symptoms related to delayed onset muscle pain (George P. Elias, Wyckelsma, Varley, McKenna, & Aughey, 2013a; Montgomery et al., 2008; Greg J. Rowsell, Coutts, Reaburn, & Hill-Haas, 2009; Stanley, Buchheit, & Peake, 2012).

The perception of fatigue and levels of creatine phosphokinase (CPK), another study to realize by (Peiffer et al., 2009), whose aim was to examine the effects of 20-minute ( $14^{\circ}\text{C}$ ) immersion on neuromuscular function, recommendations were made to suggest that temperature and duration Optimal CWI for performance-based exercise recovery and management of exercise-induced muscle damage are at  $10\text{-}15^{\circ}\text{C}$  and 5-15 min (G. et al., 2013; Machado et al., 2016).

Most of these studies compared CWI under control or passive recovery, using continuous dips (Kwiecien, McHugh, & Howatson, 2018; Machado et al., 2016; Stanley et al., 2012; Stevens et al., 2017). On the other hand, CWI has also been used through the fractional method. The results concluded that this form of immersion has no effect on the athlete's recovery and performance (Johnston, Gabbett, & Jenkins, 2015; G.J. Rowsell, Coutts, Reaburn, & Hill-Haas, 2010). In addition, another study (A. Ascensão et al., 2011) reports positive effects on recovery using CWI intermittently. These contradictory results make necessary the deeper exploration of these approaches to be able to bring objective and weak answers.

Moreover, despite the wide dissemination and use of this recovery technique (G. et al., 2013), to our humble knowledge, only one study has explored the use of this technique in Handball players (Sanchez-Ureña et al., 2015). The protocol to use was that of the split CWI. The results showed a positive effect on handball recovery. However, no study has explored the effects of the two methods on recovery among sportsmen and women in team sports.

The advanced physiological mechanisms when using fractional immersions show a pumping effect caused by vasoconstriction and vasodilatation, which occur due to temperature change. This pumping effect stimulates the transport of waste and nutrients into the body (Higgins et al., 2017). In contrast, continuous immersions are advocated as a result of increased exposure to cold and the effects of vasoconstriction and hydrostatic pressure which together facilitate processes such as, rapidly decreasing body temperature, and acceleration of processes associated with decreased pain (Ihsan, Watson, & Abbiss, 2016)

## Literature Review

Through this literature review, we assume that the response of the recovery indicators varies significantly depending on the type of CWI recovery protocol. Therefore, the main objective of this study is to compare the effects of two recovery protocols by CWI after a state of intense fatigue in young Handball players.

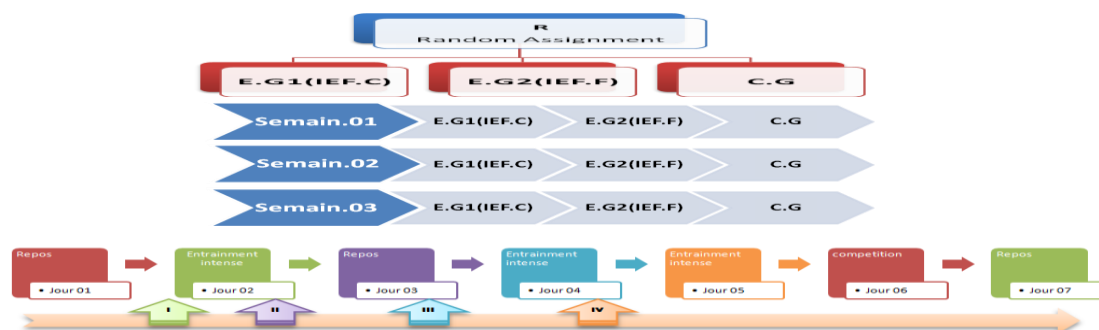
## Method

### Participants

The subjects who voluntarily participated in this experiment were Hand Ball players between 14 and 15 years of age ( $15 \pm 1.4$  years of age) and a body weight of  $67.2 \pm 5.1$  kg, with a height of  $176 \pm 3.02$  cm. Their sporting experience was ( $5 \pm 2$  years) on average. They trained three times a week. Each training session lasts 1 hour and a half. In addition, the entire team regularly participated in one competition once a week, for a total of 12 competitions during the pre-competitive period (Fig. 1). The experimental procedures, the associated risks and benefits were explained to each player through a consent form signed by the parents.

Subjects were homogeneously distributed A balanced design was applied in which subjects in Experimental Group 1 received the abstract (CWI.C), subjects in Experimental Group 2 received the abstract (CWIF) and subjects in the Control Group received the abstract (GC). This population was passively recovered, as shown in Figure 1, and this study was conducted prior to the competition period.

The study was designed in accordance with the recommendations for clinical research in the Declaration of Helsinki (General Assembly of the World Medical Association, 2014). The protocol was reviewed and approved by a committee of experts from the Institute of Physical Education and Sport of the University of Mostaganem (Algeria).



**Figure 1.** Training protocol representation of three groups Cold water immersion.

## Materials and Methods

### Body composition and anthropometric measurements

The mass index was determined using a model (Tanita BC-1500, Japan 2015) with an accuracy of  $\pm 0.1$  kg. The height was measured using a wall stadiometer. The Percentage of fat was calculated using a skin fold caliper, data from 7 sites (chest, medial-axillary subscapular, triceps, supriliac, abdomen and thigh)(Hoppe, Brochhagen, Baumgart, Bauer, & Freiwald, 2017; Karan et al., 2017) were evaluated. All measurements were made with an anthropometric measurement calculation tool (Houcine, Ahmed, & Saddek, 2014). The water

temperature was monitored and recorded using a DeltaTrak digital thermometer, model 12207 (Lima, Peru) at 1-minute intervals.

## **The Performance and Recovery Indicators**

### **Perceived pain**

The visual analog scale (VAS 0-10) was used to measure the pain perceived by the subjects. In this case, zero (0) indicates no pain and ten (10) indicate extreme pain. To determine the level of pain, subjects were asked to perform the 90-degree chase test and indicate the perceived muscle pain in the thigh. This method has already been used in pain perception after intense exercise (Argus et al., 2017; A. Ascensão et al., 2011; George P. Elias et al., 2013a; G.J. Rowsell et al., 2010).

The circumference and volume of the thigh were measured using an anthropometric tape measure. Circumference was measured at two locations on the leg, under the buttock and above the knee. A marker was used to ensure the reliability of the re-test (before the recovery protocol and at 24 and 48 hours respectively after recovery). These data allow the calculation of thigh volume, which is an indicator of inflammation and muscle damage (Peiffer et al., 2009). The formula updated by (Hammami et al., 2018; Katch & Katch, 1974; Mudie, Gupta, Green, Hobara, & Clothier, 2017; Tidhar et al., 2015) was used to calculate muscle volume as follows:

$$\text{Vol} = h/12 \times \Pi \times [C1^2 + C2^2 + (C1) \times (C2)]$$

Note: h = high thigh;  $\Pi = 3,14$ ; C1 = Sub-gluteal circumference; C2 = above knee circumference

### **The counter-movement jump test (CMJ)**

The measurements were made using a force platform. Three tests were performed with a recovery time of 2 minutes, and the best jump was recorded for each measurement episode. The jump countermovement test (CMJ) has an intra-class correlation reliability (CIC=0.98) (Markovic, Dizdar, Jukic, & Cardinale, 2004). All variables were measured before and immediately after the recovery (from 0 hours) and at 24 and 48 hours after cold water immersion.

### **Procedure**

The anthropometric characteristics of the subjects in our sample were measured two days before the protocol (Houcine et al., 2014). Reference measurements for the dependent variables were controlled two hours before the experimental protocol was applied. Recovery and variable performance were measured in the following order: muscle pain perception, muscle volume and circumference and counter movement jump test. In addition, participants were instructed to abstain from caffeine for 24 hours, in order to avoid intense exercise for 8 hours before the test and to maintain their normal diet before the two days of the test (Cherara, Belkadi, Asli, & Benbernou, 2019).

### **The Fatigue Protocol**

Subjects underwent three 90-minute sessions. The objective was to focus on training technical and tactical skills (average HR:  $160 \pm 15.81$ ,  $156 \pm 5.53$  and  $156 \pm 12.24$  bpm, respectively). The structure of the training sessions was similar. It was composed of 10 minutes of activity on technical and tactical skills, 5 minutes of active stretching and 75 minutes of training divided into 7-8- 10 minutes of tasks.

Participants followed the three study conditions: the CWI.C protocol (12 min by immersion with temperature at  $12 \pm 0.4$  °C), the CWI.F protocol (4 times x 2 min immersion with temperature at  $12 \pm 0.4$  °C +1 min out of water at room temperature) and the control group (passive recovery, 12 minutes sitting). This protocol was chosen because the threshold temperature should be between 5 and  $-20$ °C and immersion time between 5 and 15 minutes, These thresholds were recommended by(G. et al., 2013; Machado et al., 2016) who noted that protocols with temperatures ranging from 11 °C to 15 °C for 10 to 15 minutes has a positive effect only on protocols with a temperature between 5 °C and 10 °C with an immersion time of less than 10 minutes.

The dives were carried out in a 5 x 2.4 metre inflatable pool. Ice was used to lower the water temperature. The subjects were seated during the immersion, with their legs fully extended. The dives were carried out immediately after the training session. The dependent variables were measured again at 0 hours and immediately after the recovery protocol and again 24 and 48 hours after the session, in the same order as the reference measurements.

### The statistics

Descriptive statistics (mean and standard deviation) were calculated for all variables. The normality of the data was assessed using the Shapiro-Wilks test. The results indicated normality for all variables except muscle volume and MJF performance, which were analyzed in terms of percentage change from the previous value. Since the values of these two variables were not normally distributed, another non-parametric statistical analysis was performed, using the Kruskal-Wallis H test. The other variables were analyzed with their own units of measurement. The Levene test was used to analyze the homogeneity of variances. Repeatedly measured ANOVAs were used to compare post-exercise muscle pain at 0, 24 and 48 hours after exercise. Bonferroni post hoc analysis was used.

### Results

**Table 1.** The mean scores of experimental and control groups are nearly the same, indicating equality of two groups regarding their knowledge of targeted structures.

variables	PMP baseline	0H	A:24H	A:48	TMV(m m):	0H	A:24H	A:48	CMJ (cm):Aft	0H	A:24H	A:48	
<b>CWI.C</b>	<b>mean</b>	4,32	2,31	2,52	2,26	4726,03	4663,6	4520,9	4566,9	44,2	43,61	43,03	43,94
	<b>SD</b>	1,63	1,17	1,61	1,2	850,2	843,8	840,5	983,5	5,6	4,89	4,8	5,06
<b>CWI.F</b>	<b>mean</b>	4,86	3,24	2,73	2,55	4735,8	4662,9	4782,1	4703,9	44,7	43,9	43,56	44,64
	<b>SD</b>	1,52	1,56	1,48	1,06	1180,5	1213,4	1122,8	1248,1	4,63	4,94	4,06	4,97
<b>G.C</b>	<b>mean</b>	4,63	5,81	5,02	4,53	5065,9	4934	4894,3	4886	46,76	46,93	45,6	43,3
	<b>SD</b>	1,67	1,59	1,54	0,83	1084,6	1184,2	1102,9	1129,5	7,6	6,95	7,2	7,49

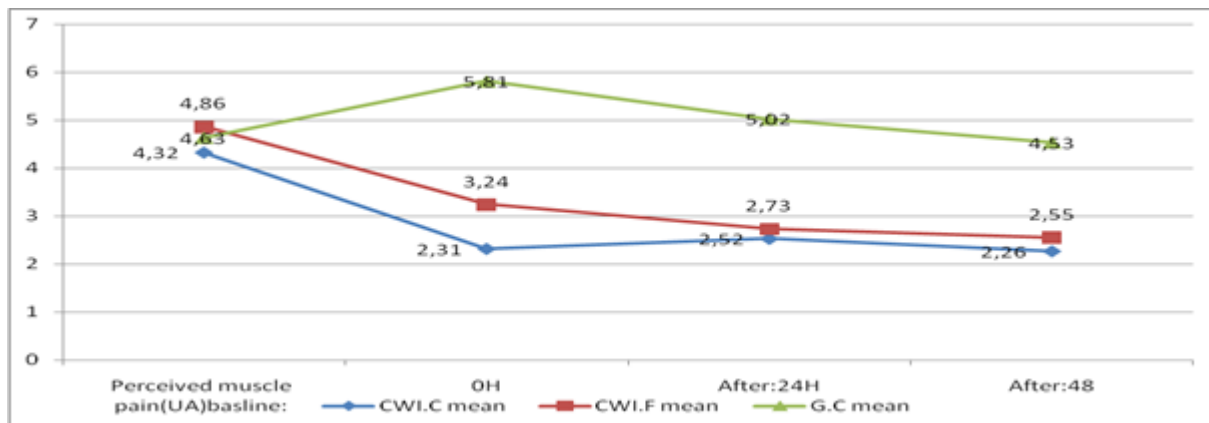
Before: before training

G.E 1 (CWI.C): Experimental group with the Continuous Cold Water Immersion Protocol.

G.E 2 (CWI.F): Experimental group with the Fractionated Cold Water Immersion Protocol.

G C: Group control.

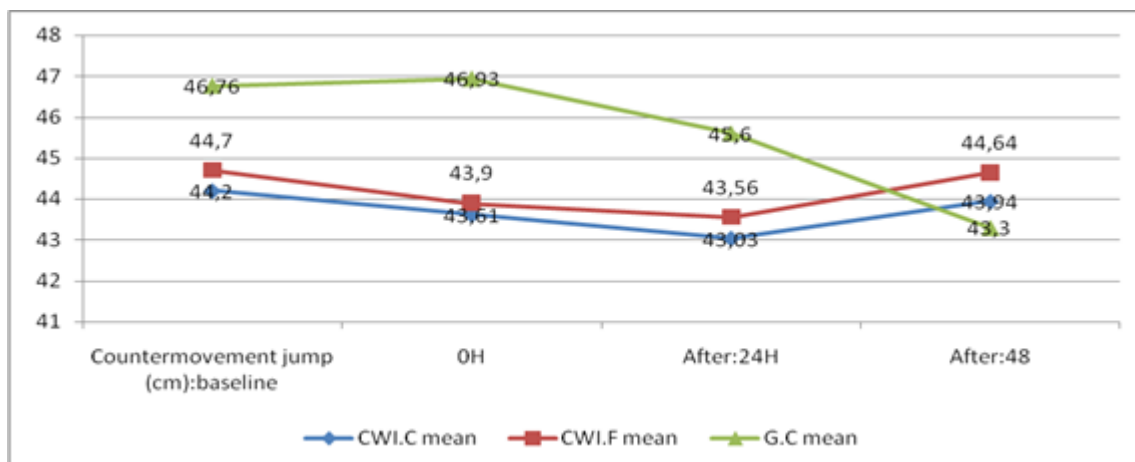
Table 1 above presents descriptive data for the variables associated with recovery for each of the experimental conditions (CWI C, CWI F, and GC) at different measurement times. Statistically significant differences do not appear for pain perception and counter-jump movement ( $p < .05$ ); details are presented in (Figure 2).



**Figure 2.** Shows the perception of muscle pain and its tendency between the 3 groups.

Figure 2 above shows a significant interaction ( $F(3.92) = 3.62, p = 3.16, p = .24$ ) with the two immersion protocols (CWI.C CWI.F) and significantly reducing pain perception compared to GC (passive recovery) perceptions in measurements immediately after immersion (CWI.C Vs CG,  $p < .001$ ) (CWI.F Vs CG,  $p = .009$ ), at 24 hours (CWI.C Vs CG,  $p = .021$ ) (CWI.F Vs CG,  $p = .024$ ) and 48 hours after immersion (CWI.C Vs CG,  $p = .017$ ) (CWI.F Vs CG,  $p = .032$ ).

Statistically significant differences were not reported when comparing the reference value with the post-immersion measurements. In addition, statistically significant differences were not reported ( $p < 0.05$ ) at any of the measurement times when comparing the continuous immersion group with the split immersion group. Change CMY test CMY 0% (CWI.F 1 \* inverted values) CWI.C 2 Pre-Post Exec. 24 hours 48 hours of significant difference with respect to the control group ( $p < 0.05$ ), CG: control group.



**Figure 3.** Shows the counter movement jump between the 3 groups CMJ (%)

Figure 3 above shows statistically significant differences in jump ability by analysis using the MJF test at 24 hours ( $Z = 12.62, p = 0.004$  when CWI.C; CWI.F comparison and with GC (passive recovery) (CWI.C vs CG,  $p = .006$ ) (CWI.F vs GC,  $p = 0.029$ ) and 48 hours after training ( $Z = 16.22, p < 0.001$ ), (CWI.C Vs. CG,  $p < 0.001$ ) (CWI.F vs CG,  $p = 0.017$ ). In addition, no statistically significant differences ( $p < 0.05$ ) were reported when comparing the two groups that were continuously immersed with the fractionated group. Concerning muscle volume, the analysis did not show any significant interaction ( $F(3.54) = 2.42, p = 0.058$ ).

## Discussion and Conclusion

The main purpose behind conducting this study was to examine the effect of The purpose of this study was to explore the effects of two cold water immersion protocols: the CWI C protocol (12 min immersion at  $12 \pm 0.4^{\circ}\text{C}$ ) and the CWI F protocol (4 times x 2 min immersion at  $12 \pm 0.4^{\circ}\text{C}$  + 1 min out of water) after intense exercise on recovery. The main finding of this study is that both immersion protocols are effective in reducing signs of fatigue and delaying the onset of muscle pain. The analyses also showed positive effects on the recovery of jump capacity measured using the CMJ jump test.

In the case of (Simmons, Cooper, Research, & Muse, 2018), continuous immersion in cold water as part of the 12-minute protocol at  $12 \pm 0.4^{\circ}$ , the latter proved effective in reducing muscle pain immediately after immersion and at 24 and 48 hours after intense exercise. These results are not consistent with the work of (Glasgow, Ferris, & Bleakley, 2014; Stevens et al., 2017) but with those reported by (Delextrat, Calleja-González, Hippocrate, & Clarke, 2013; Greg J. Rowsell et al., 2009; Stanley et al., 2012) which indicate that cold water reduces the functional and physiological signs associated with muscle pain (Lauber, Hickle, Jargstorf, & West, 2017) and confirm that the use of this protocol for CMJ is effective. These results further reinforce protocols with temperatures ranging from  $11^{\circ}\text{C}$  to  $15^{\circ}\text{C}$ , with an immersion time of 10 to 15 minutes that have a positive effect (Lauber et al., 2017) and that MJF techniques appear to be more effective in accelerating performance restoration in different sports by using immersions 5 to 15 minutes at a water temperature of  $5\text{-}20^{\circ}\text{C}$  (Versey, Halson, & Dawson, 2013).

In addition, in fractional dives under the 4 x 2 min immersion protocol with a water temperature of  $12 \pm 0.4^{\circ}\text{C}$  + 1 min above water at room temperature, the results obtained disagree with those reported by (A. F. Machado et al., 2017). When used, the 3 x 1 min protocol of immersion at  $5 \pm 1^{\circ}\text{C}$ , with 1 min out of water, does not report positive effects on DOMS on a comparison of the experimental group with the control group.

Our results are consistent with those reported by (A. Ascensão et al., 2011) who used a 5 min x 1 protocol ( $10 \pm 0.5^{\circ}\text{C}$  + 1 min out of water) at room temperature and reported positive effects of intermittent immersion. These concordances with research results were reported by (António Ascensão, Leite, Rebelo, Magalhães, & Magalhães, 2011) who found significant differences both immediately after the immersion protocol and 24 hours after training compared to the control group.

Similarly, (Sánchez-Ureña et al., 2017) reported significant differences at 24 hours after training between the fractionated immersion group and the control group, using the 2 x 5-minute immersion protocol with water temperature at  $10^{\circ}\text{C}$  and 2.5 minutes out of water at  $21^{\circ}\text{C} \pm 0.5$ . This study is the first to report these differences both immediately at 24 and 48 hours after exercise, indicating that the protocol used was characterized by the reversal of the previous protocol.

These physiological results demonstrate that the physiological and functional symptoms associated with Post-Effort Muscle Pain (EPMP) associated with the reduction of acute inflammation (Vaile et al., 2007), as well as the presence of symptoms in the muscle and the effect of hydrostatic pressure (George P. Elias et al., 2013a; Washington et al., 2000) (Leeder et al., 2012) have accelerated recovery. Another mechanism could be related to cold exposure that has shown the potential for activation of the transient 8-melastatin receptor (Wang & Siemens, 2015) which is related to pain and temperature sensation (Knowlton et al., 2013; Proudfoot et al., 2006). Once activated, TRPM8 has an analgesic effect given by the action of

the interphas neurons the inhibitory interphase (Knowlton et al., 2013) and which improves the perception of DMPE and increases the feeling of recovery (Ihsan et al., 2016).

It is also important to note that exposure to cold causes changes in the neurotransmitters of dopamine and serotonin, which are responsible for regulating mood, sleep, emotions, motivation, pain perception and fatigue. Cold water immersion may help to reduce central nervous system fatigue (Ihsan et al., 2016) and suggests that an increase in serotonin/dopamine ratio is associated with fatigue and the rapid onset of fatigue, while a low serotonin/dopamine ratio promotes better performance through maintenance and physiological activation.

In addition, the jump capacity measured by MJF through the two immersion protocols was found to be more effective than passive recovery. This result is consistent with the studies of (Stanley et al., 2012). Indeed, using a continuous immersion protocol, differences were also observed between this group and the control group in terms of effectiveness using the Squat Jump test 48 hours and 72 hours after exercise but not at 24 hours after exercise the exercise between the two groups.

As with cold water immersion, (António Ascensão et al., 2011), the use of a five-minute protocol after the end of the competition to 2 split dives of the lower limbs (to the iliac crest) in a cold water bath (11°C), separated by 2 min in ambient air (sitting, ambient temperature 20°C) resulted in statistically significant differences 24 hours after the CMJ test immersion. These results are in line with the conclusions of our study.

In addition, the results for thigh volume coincide with those reported by (Zagatto et al., 2016) who also observed that continuous immersion did not significantly decrease edema evaluated at 24, 48 and 72 hours after training. Similar conclusions have been reported by (Wilcock, Cronin, & Hing, 2006) showing that the use of a continuous immersion protocol did not lead to a significant decrease in muscle edema in the immediate posterior measurement. (Wilcock et al., 2006) also indicated that the thigh circumference (edema) which is an indicator varies less throughout cold water training in the continuous immersion and control groups. The results are identical to the results of this study. One possible explanation is that the load to which the players were exposed did not cause sufficient muscle damage to generate oedema. The results obtained in this study allow sport professionals, such as coaches and trainers (Belkadi et al., 2015) to choose the best protocol for their athletes according to their preference, given the effectiveness of both protocols.

In the field of sports training and more particularly in the field of active recovery, more work is needed to compare different cold water immersion protocols, including the measurement of biochemical variables such as creatine phosphokinase (CPK) and lactate dehydrogenase (LDH) physiological myographic surfactants as well as other variables such as reaction time (Berria, Bachir, Eddine, & Adel, 2018), contraction and muscle relaxation time. In addition, it is necessary to test different split immersion protocols that take into account immersion times, in-water and out-water relationships and temperature differences to optimize the most appropriate protocol for the type of sport.



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