Original Article

Cryotherapy post-training reduces muscle damage markers in jiu-jitsu fighters

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ABSTRACT

Santos WOC, Brito CJ, Júnior EAP, Valido CN, Mendes EL, Nunes MAP, Franchini E. Cryotherapy post-training reduces muscle damage markers in jiu-jitsu fighters. *J. Hum. Sport Exerc.* Vol. 7, No. 3, pp. 629-638, 2012. Although widely used in sports, the efficiency of cryotherapy in reducing muscle damage has been questioned. The present study investigated the acute effects of post-exercise cryotherapy on the expression of creatine phosphokinase (CPK) and lactate dehydrogenase (LDH), perceived pain, and muscle strength of the upper limbs in Brazilian jiu-jitsu competitors. Nine highly trained fighters were subjected to two 90-minute training sessions. After the first session, five random subjects were immersed in a pool with ice (5±1°C) for nineteen minutes, and the remaining participants were allocated to the control group. The treatments were reversed in the second session (cross-over design). Analysis of covariance with repeated measures was used to compare outcomes between the groups, and pre-test measures were used as covariates. Pearson's correlation was adopted to check the strength of the associations between variables. The results showed lower serum CPK concentrations (P<0.05) in the cryotherapy group (504.0±138.7 IU/L) compared to the pre-exercise (532.6 ± 67.9 IU/L) group, and a similar result was observed for LDH (517.4±190.3 vs. 601.8±75.7 IU/L). Cryotherapy resulted in lower (P<0.05) perceived pain (2.2 ± 1.6 vs. 4.2 ± 1.9) and body temperature (34.2±1.3°C vs. 36.3±0.7°C), and an attenuated loss of isometric strength (53.1±18.1 s vs. 42.9±14.5 s). Perceived pain was directly associated (P<0.05) with CPK (r=0.59) and LDH (r=0.475) levels. The results show that post-exercise cryotherapy resulted in lower serum CPK and LDH, hypoalgesia, and greater preservation of isometric strength endurance when compared to the control condition. **Key words**: COLD WATER IMMERSION, MARTIAL ARTS, CREATINE KINASE, L-LACTATE DEHYDROGENASE, MUSCLE STRENGTH.

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INTRODUCTION

The preparation of high performance fighters requires hard physical effort (Franchini et al., 2011). However, strenuous exercise promotes biochemical and cellular changes that result in deterioration of muscle structure, decreasing the capacity to perform intense exercise (Kim et al., 2007). Due to potential interference with athletic performance (Kim et al., 2007; Kim et al., 2009; Neubauer et al., 2008), muscle damage from high-intensity exercise has been the target of several investigations. Creatine phosphokinase (CPK) and lactate dehydrogenase (LDH) are among the most investigated markers of muscle damage (Kim et al., 2007). The increase in CPK arising from exercise is directly related to the appearance of Delayed Onset Muscle Soreness (DOMS) (Nieman et al., 2005) as well as increased expression of markers for cartilage injury (Kim et al., 2007). Moreover, the increase in serum concentrations of CPK after exercise is inversely proportional to the ability of muscle to produce force (Skurvydas et al., 2011). LDH is present in large amounts in skeletal muscle because it is responsible for the anaerobic conversion of pyruvate to lactate. The combination of LDH enzyme in the muscle damage is closely related to the increased concentration of CPK (Thompson et al., 2004).

Because training volume must be maintained for high performance athletes, methods to reduce muscle damage post-exercise have been investigated (Torres et al., 2012). Cryotherapy has been widely used following training, although there is little scientific evidence supporting its efficacy (Leeder et al., 2012). To date, the physiological effects (Hubbard & Denegar, 2004; Torres, et al., 2012) of cryotherapy are unknown. However, cold water immersion is speculated to cause peripheral vasoconstriction and reduce inflammation, which consequently reduces pain and results in greater muscle recovery (Yanagisawa et al., 2003).

Increasing the speed of recovery is an important strategy, especially for competitive athletes involved in prolonged training cycles (Leeder et al., 2012). In combat sports, especially those involving grappling (e.g., judo, wrestling, or jiu-jitsu), quick recovery becomes relevant because competitive athletes are highly susceptible to injury from trauma (Green et al., 2007). Reducing muscle damage after training would help protect the health of athletes, thus increasing the chances that preparatory training cycles could be established and completed (Leeder et al., 2012). To our knowledge, no studies have investigated the effects of cryotherapy on the muscle damage of competitive fighters. The objective of this study was to investigate the acute effects of cryotherapy after training on the blood concentration of the enzymes CPK and LDH, pain perception, and both muscle strength and endurance of the upper limbs in Brazilian jiu-jitsu competitors. It was hypothesized that intervention with ice minimized muscle damage, resulting in lower perception of pain and greater preservation of isometric and dynamic strength.

MATERIAL AND METHODS

The present study utilized a crossover design where two training sessions were separated by two days. The athletes' training regimen represented a typical training session characterized by progressive and comprehensive effort. Each workout was composed of the following: a) 30 minutes of general exercise; b) 30 minutes of technical training; and c) finally, 30 minutes of fighting. General exercise training (gymnastics) was composed of warm-up exercises involving strength, speed, and endurance. Technical training was composed of specific movements, including guard passes, sweeps, arm-locks, submissions, and projections. The combat stage was composed of five matches (five minutes of activity separated by one-minute intervals). All subjects were previously familiar with the system of training and procedures employed. This study was approved by the Ethics Committee of the Federal University of Sergipe (CAAE

Protocol-01723312.2.0000.0058), and met the guidelines of Resolution 196/96 dated 10/10/96 from the Brazilian National Council of Health for human experimentation.

Participants

We selected nine contestants that were highly trained males (age: 23.0 ± 4.4 yrs; BM: 68.0 ± 2.8 kg; height: 173.3 ± 1.7 cm; body fat: 12.7 ± 3.5%), experienced in competition (5.2 ± 2.5 yrs), and belonging to the GFTeam. All athletes were selected because they had at least three years of training experience in Brazilian jiu-jitsu and had participated in at least three competitions in the past year. Prior to participation, all subjects were informed about the procedures to be adopted and potential risks and benefits and were asked to sign a consent form. All volunteers were in the final stage (30 days) of preparation for the state jiu-jitsu championship, and had not experienced rapid weight loss during the week preceding data collection.

Measures

Anthropometric measurements were performed on all athletes prior to the study. Body mass was measured with a scale calibrated to a maximum capacity of 200 kg and a precision of 100 g (Soehnle®, SP, Brazil). Height was measured by a stadiometer attached to a scale (accurate to 1 cm). Body composition was estimated indirectly by means of equations that use skinfold thicknesses (Lange Skinfold, MA, USA). Body density was estimated using a specific equation for college wrestlers (Thorland et al., 1991). The percentage of body fat (% BF) was estimated from the equation of Brozek et al. (1963).

Procedures

Fighters were asked to abstain from training or any strenuous physical activity 24 hours before the experiment. On the first day, five athletes were randomly chosen to receive post-exercise cryotherapy, and the remaining athletes were in the control group. The treatments were reversed on the second training day. Immediately after the training session, these athletes were immersed in an ice bath (5±1°C) for 19 minutes, which consisted of four cycles of four-minute immersions separated by one-minute intervals.

Markers of muscle damage

Serum CPK and LDH were measured as indicators of muscle damage. Blood samples were drawn prior to training and at the end of cryotherapy. We extracted two mL of blood from a vein superficial to the cubital fossa, and the blood was placed in tubes containing coagulant gel (Vacuette®, Greiner Bio-one, Campinas, SP, Brazil). The blood stood for 30 minutes at room temperature to promote coagulation and was then centrifuged for eight minutes at 2500 rpm for serum separation. Biochemical determinations were performed with the Vitros 5600 Integrated System (Ortho-Clinical Diagnostics, Johnson & Johnson Company, Rochester, NY, USA). Both LDH and CPK were measured using kinetic enzyme analysis with multiple time points.

Upper limb strength

Before training and after recovery, all athletes performed the Judogi Handgrip Test, an isometric and dynamic strength endurance test, as proposed by Franchini et al. (2011). The test consists of performing exercises involving static and dynamic strength endurance. Initially, the fighters performed the isometric test by holding a kimono wrapped around a horizontal bar with the elbow flexed. After 15 minutes of rest, the dynamic test began. The same handgrip position was used during this test. However, full repetitions were performed starting from the initial test position (elbows fully flexed) to full arm extension. Both tests were performed until fatigue. This test exhibited good reproducibility (dynamic test-intraclass correlation coefficient=0.99, limits of agreement=-2.9 to 2.3 repetitions; isometric test-intraclass correlation coefficient=0.97, limits of agreement=-6.9 to 2.4s) (Silva et al., 2012).

Perception of pain

Athletes indicated their perception of pain using the Visual Analogue Scale, which is characterized by a 10-point rating scale (0 = no pain, 1-3 = weakly intense pain, 4-6 = moderate pain, 7-9 = severe pain and 10 = unbearable pain intensity). Pain scores were obtained before training, after training, post-recovery, and after performing the Judogi Handgrip Test as described by Carvalho and Kovacs (2006).

Body temperature

The temperature of the athletes was measured using a digital thermometer (G-Tech®, RI, USA) before training, after training, and post-recovery. Figure 1 shows a diagram that illustrates the variables measured and the associated time points.

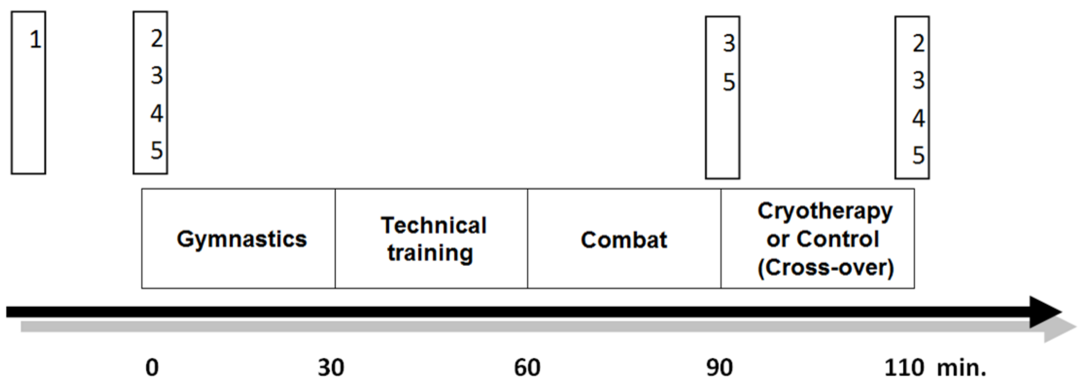

Figure 1. *Schematic representation of the procedures used for data collection. Figure bars refer to time points for variables measured before, during and after training sessions. Variables measured are represented inside the bars as follows: a) 1 = anthropometry b) 2 = Judogi Handgrip Test; c) 3 = body temperature; d) 4 = blood collection; and e) 5 = perceived pain.*

Statistical analysis

We conducted exploratory data analysis for the identification and correction of extreme values. The Shapiro-Wilk test was used to test the null hypothesis. We adopted the analysis of covariance (ANCOVA) with repeated measures to compare group means, and pre-test measures were used as covariates. To validate the repeated measures, we adopted the Mauchly sphericity test and, where necessary, the Greenhouse-Geisser correction was used. The Bonferonni method was used for post hoc comparisons when the ANCOVA results were significant. Cohen (1992) was used to estimate the magnitude of treatment effects between groups, and the Pearson correlation was used to verify the relationship between variables. In all analyses, we used a significance level of $P<0.05$.

RESULTS

Figure 2 shows the values of CPK and LDH pre- and post-recovery in the two experimental conditions.

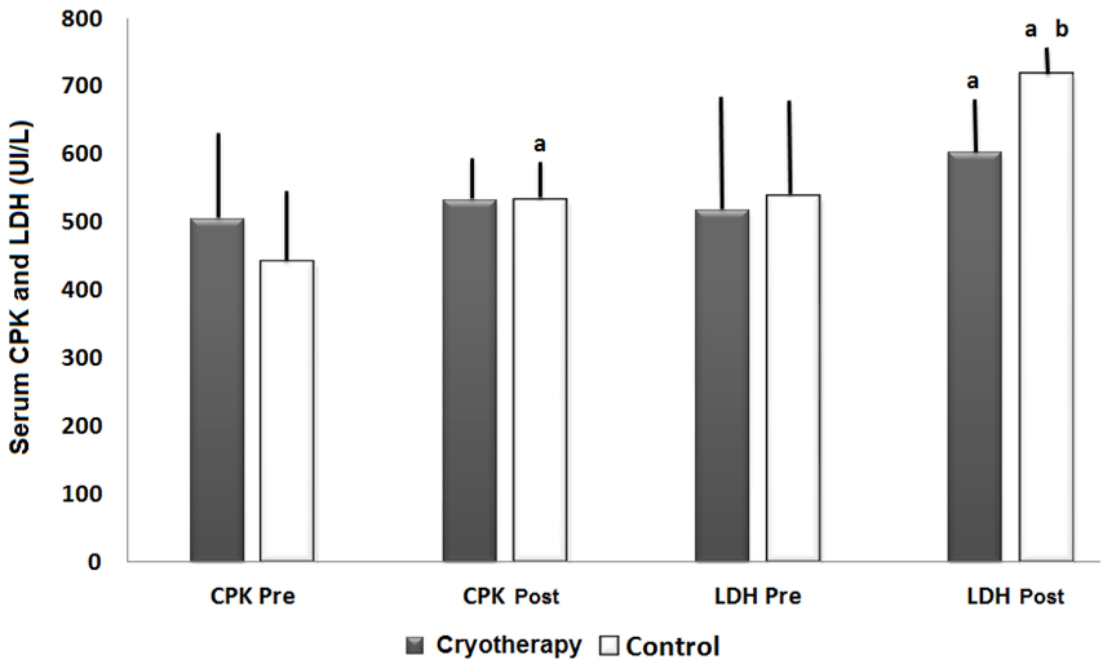

Figure 2. *Serum creatine phosphokinase (CPK) and lactate dehydrogenase (LDH) pre-training (Pre) and post-recovery (Post). a P < 0.05 compared to baseline in the same condition. b P < 0.05 compared to final values between conditions.*

Serum levels of CPK were only significant increased for the control condition (F=33.92, P<0.05, d=0.17). LDH increased significantly in both conditions (F=26.74, P<0.05, d=0.8) when compared to pre-training, but post-recovery values were significantly higher (P<0.05) in the control condition when compared to cryotherapy. Table 1 shows the results for the dynamic and isometric force tests.

Table 1. *Isometric and dynamic strength endurance pre- and post-recovery for the cryotherapy and control conditions.*

Strength endurance		Pre-training	Post-recovery
Isometric (s)			
	Cryotherapy	61 ± 20	53 ± 18
	Control	63 ± 19	43 ± 15[a]
Dynamic (rep)			
	Cryotherapy	15 ± 2	13 ± 5
	Control	15 ± 2	13 ± 6

S = seconds, rep = repetitions. [a]Significant difference between the pre-training for the same condition ($P < 0.05$).

A decrease ($F = 16.9$, $P < 0.05$, $d = 0.4$) in strength was observed only for the control condition. Table 2 shows the values for the estimated perception of pain.

Table 2. *Subjective perception of pain pre-training, post-training, post-recovery, and post-judogi handgrip test (JHT) in cryotherapy and control conditions.*

Pain Cond.	Pre-training	Post-training	Post-recovery	Post-JHT
Cryotherapy	1.3 ± 1.1	5.0 ± 1.6[a]	2.2 ± 1.6	3.0 ± 1.2
Control	1.3 ± 1.0	4.7 ± 1.9[a]	4.2 ± 1.9[b]	4.4 ± 1.1[a]

Cond. = Condition, [a] significant difference between this point and the pre-training, [b] Significant difference between values post-recovery between conditions ($P < 0.05$).

Perceived pain increased significantly between the beginning and end of training ($F=5.64$, $P<0.05$, $d=1.4$). However, cryotherapy resulted in hypoalgesia, which was not observed in the control condition ($F=0.18$, $P>0.05$, $d=1.2$). Table 3 shows values for the body temperature measured at different times.

Table 3. *Body temperature pre-training, post-training, and post-recovery in the two experimental conditions.*

Temp. / Cond.	**Pre-training** (°C)	**Post-training** (°C)	**Post-recovery** (°C)
Cryotherapy	35.9 ± 0.7	38.0 ± 0.7	34.2 ± 1.3[a]
Control	36.2 ± 0.6	37.2 ± 0.9	36.3 ± 0.7

Temp = Temperature, [a] Significant difference between this point and post-training values (P<0.05).

There was no significant increase in body temperature between the beginning and end of training sessions (F=1.04, P<0.05, d=0.3), however, body temperature decreased significantly (F=19.99, P<0.05, d=0.4) between the time after training and the end of recovery for the cryotherapy condition. Table 4 shows the correlations for the variables measured. The levels of CPK and LDH were significantly (P<0.05) correlated with perception of pain. There was also a significant correlation between the concentrations of CPK and LDH.

Table 4. *Pearson's correlation between enzymatic, perceptive pain, temperature and performance variables.*

	Pain	**LDH**	**Isometric**	**Dynamic**	**Temp.**
CPK	0.59[a]	0.34[a]	0.087	0.165	0.216
Pain		0.475[a]	-0.295	0.63	0.75
LDH			-0.193	-0.193	-0.105
Isometric				0.636[a]	0.018
Dynamic					0.055

Temp = Temperature, [a] Significant correlation (P < 0.05).

DISCUSSION

The present study showed that immersion in low-temperature water post-training resulted in reduced serum CPK and LDH, hypoalgesia, and greater preservation of isometric strength endurance. The contribution of cryotherapy in post-exercise recovery was questionable (Leeder, et al., 2012). Measurement of CPK and LDH levels has been widely used when estimating muscle damage resulting from high-intensity exercise. Muscle damage has resulted in leakage of fluid into extracellular space, thereby increasing serum LDH and CPK (Lippi et al., 2011; Wilcock et al., 2006). Therefore, lower serum levels of CPK and LDH after cryotherapy are indicative of less muscle damage arising after immersion in ice (~5°C).

It is important to emphasize that isometric testing was performed immediately after recovery, and the hypoalgesia caused by cryotherapy may have assisted in enhancing test performance. However, immersion in ice did not influence the dynamic strength test because there was a rest period (15 minutes) that may have been long enough to promote full recovery. Using the same time frame, studies (Franchini et al., 2009; Franchini et al., 2003) with judo fighters undergoing competitive simulations have indicated that well-conditioned individuals recover the ability to perform high-intensity intermittent activities (i.e., four Wingate tests separated by three-minute intervals, performance in the Special Judo Fitness Test, and a number of attacks comprising a new match simulation). In the present study, the time interval represented the sum of the 19-minutes interval devoted to cryotherapy (4 x 4 minutes with one-minute intervals between interventions) with 15 minutes between the end of isometric testing and dynamic testing. It is very likely that, even in the control condition, the athletes were entirely recovered prior to implementation of the dynamic strength test.

According to Wilcock et al. (2006), hypoalgesia resulting from cryotherapy can remain after the exercise, resulting in reduced perception of muscle wasting. In contrast to our results, Yamane et al. (2006) observed that cryotherapy did not interfere with maximal isometric strength but adversely affected momentum. Indeed, submersion in water at a low temperature (5±1°C) results in vasoconstriction, and the diameter of the brachial artery (Yamane, et al., 2006) decreases by 0.5 mm. Douris et al. (2003) demonstrated a reduction in maximum isometric strength of forearm muscles after immersion in water at 10±1°C for periods of 5, 10, 15, and 20 minutes. Leeder et al. (2012) showed that cryotherapy was not effective in the recovery of maximum force but assisted in maintaining muscle power, although the authors did not present the possible mechanisms involved.

The subjective perception of pain was lower in the cryotherapy condition, confirming findings from previous studies (Ascensao et al., 2011; De Nardi et al., 2011). Gregson et al. (2011) showed that cryotherapy reduced perceived pain by lowering the osmotic pressure of exudate (metabolites arising from inflammation), which consequently signals the afferent projections of nerve branches. Furthermore, the resulting vasoconstriction reduced the concentration of liquid in the interstitial space, thus reducing muscle inflammation. During the isometric endurance test, discomfort was great in the final seconds. The fact that the test began with a lower perception of pain may have contributed to the drop in performance compared to the pre-training session.

In our study, we observed that a reduction in pain was associated with decreased skin temperature after cryotherapy because the average temperature was approximately 2°C lower compared to the control condition. Accordingly, peripheral vasoconstriction occurs to preserve central heat (Wilcock, et al., 2006), which may have contributed to the lower perceived pain. These data show beneficial effects of cryotherapy in acute fighters, especially in the relevant variables (i.e., isometric strength endurance) for performance in maintenance mode in which the gripping is constant (Silva, et al., 2012). However, new studies should be performed to confirm these results and monitor the late effects of immersion because concentrations of CPK and LDH peak between 48 and 72 hours post-exercise (Cooke et al., 2010).

CONCLUSIONS

Cryotherapy post-training (5 ± 1oC) results in lower serum concentrations of CPK and LDH, hypoalgesia, and maintenance of isometric strength endurance when compared to the control condition.

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