Original Article

Influence Of Continuous Airflow Cryotherapy On Serum Creatine Kinase Level In Induced Muscle Soreness In Healthy Subjects: A Randomized Control Trial

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Abstract

Background: Delayed onset muscle soreness is a type of muscular pain which happen when unsusal movements, including violent as well as unexpected physical actions of great intensity, are achieved. In this study, we investigate the impact of continuous airflow cryotherapy on serum Creatine Kinase level, pain intensity, and elbow flexion and extension range of motion (ROM) in induced muscle soreness in healthy subjects. **Methods:** Thirty healthy untrained male volunteers were recruited randomly to the study among the surrounding population. The participants were randomized into two groups of equal number, fifteen in each group. Group A received the airflow cryotherapy treatment on the non-dominant arm beside rest and home instructions, while group B received rest and home instructions. The procedure includes 4 phases, Baseline measurements (pre-induction) (serum creatine kinase for soreness, visual analogue scale (VAS) for pain intensity measurement, and goniometer for elbow joint ROM) were taken**. Results**: there was a significant enhancement in serum CK level, pain intensity, as well as elbow ROM elbow (flexion /extension) of the study group in comparison with the control group at post I in addition to post II. **Conclusion:** continuous airflow Cryotherapy is used to improve function and help patients get back to their pre-injury level of function as soon as possible.

Keywords: Delayed onset muscle soreness, creatine kinase, continuous airflow cryotherapy

INTRODUCTION

Muscles are more likely to experience delayed-onset muscle soreness (DOMS) after being subjected to intense, unfamiliar exercise, particularly which involves eccentric contraction (lengthening contraction, LC). It is characterized by mechanical hyperalgesia (tenderness and movement-concerned pain). Previous explanations have pointed to inflammation caused by micro tears in the muscle fibers **(Mizumura and Taguchi, 2016).** Pain, weakness, a shortening of the muscle, and impaired proprioception are all symptoms of DOMS, which is caused by a shortage of blood and oxygen reaching the contracting muscle **(Cheung et al., 2003).**

Tenderness in the muscles is one sign of DOMS, but the pain can be severe at times. Muscle ligaments and tendons could be subjected to excessive stress if muscle sequencing and activation patterns were changed "(Cheung et al., 2003)" Several studies are looking into potential solutions to prevent DOMS. Neither prevention nor treatment have been developed for DOMS because its underlying mechanisms are still unclear (Barnett, 2006).

Some forms of resistance training involve lengthening (eccentric) movements, which take place when the muscle fails to resist lengthening and instead acts as a brake. However, muscular damage can occur if the muscle is lengthened during contraction; this is manifested in a persistent reduction in ROM and the development of DOMS. The effects of this type of exercise usually reach their peak within one to three days, and then they gradually subside throughout seven to ten days. According to a study (Paschalis et al., 2010), (Paschalis et al., 2013).

Several therapeutic approaches have been developed for reducing DOMS. Massage, stretching, moderate exercise, immobility, as well as simple rest have all been investigated in addition to more conventional physical therapy methods like cold treatments, ultrasonic, as well as electric stimulation. Hyperbaric oxygen therapy (HBOT) is one such alternative treatment, however it is still unclear whether or not it is the best option for alleviating damaging symptoms **(Connolly et al., 2003)**

Cryotherapy modalities also promote recovery between exercise training sessions and competitive events when some athletes experience delayed onset muscle soreness (DOMS) **(James et al., 2011).** Sacks of ice cubes, commercial ice, gel packs, ice massaging, cold compression units, as well as cold whirlpools are just some of the many equipment available for the administration of cold treatment **(Nadler et al.,2004).**

The literature has been trying to clarify the role of local airflow cryotherapy on symptoms of DOMS. **Guilhem et al., 2013.**

Therefore, the main aim of this present study is to fill the literature gap and investigate airflow cryotherapy's clinical effectiveness on DOMS.

Methods

Thirty healthy, untrained male volunteers took part in the study following the Ethical Committee of the Faculty of Physical Therapy at Cairo University gave their approval, and all subjects offered written informed consent. (NO.P.T. REC/012/002243).

Volunteers were recruited to the study among the surrounding population and were enrolled via flyers around the hospital and by word of mouth. Biological variations were controlled by conducting induction at the same time of day, refraining from caffeine or food intake at least 2 h before testing.

The participants were randomized into two groups of equal number through the sealed envelope system.

Sample size

For a study including a comparison of two groups, the sample size is determined with the use of G*POWER (version 3.1.9.2) statistical software. Cryoflow therapy has been shown to significantly reduce the pain associated with DOMS, according to previous studies (Elsayed et al., 2015). According to the calculations, this study needs a total of 24 participants (12 in each of the two groups). Allocation ratio N2/N1 = 1 was used in the calculations with a significance level of 0.05, power of 80%, effect size of 1.2, and N2/N1 = 1. The number increased to 15 per group for possible dropouts.

Subjects were assigned to the study according to the following inclusion and exclusion criteria

Inclusion criteria

1. Thirty untrained healthy male volunteers will range from 20-40 years. **(Petrofsky et al., 2017)**
2. Physically active but had not performed regular resistance training or sports activities for at least six months prior to the present study,
3. BMI of 18.5–25 kg/m2

Exclusion Criteria

Subjects were excluded if they had any systemic disease affecting sensation, circulation, and CK levels.

The procedure of this study included 4 phases.

Phase1

A familiarization session was conducted one week prior to the beginning of the experimental procedure, and random allocation into 2 groups was conducted.

Phase 2

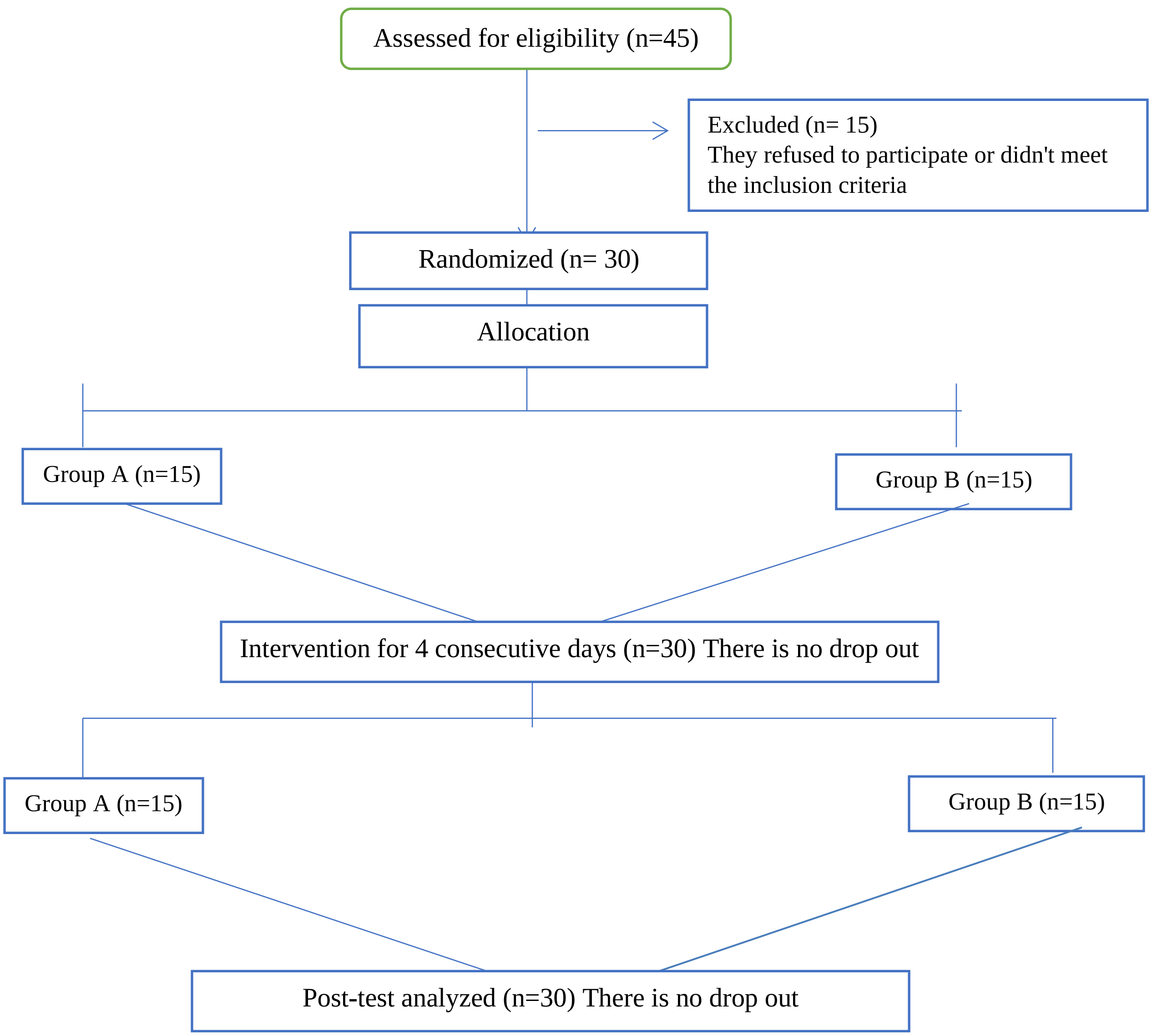
Baseline measurements (pre-induction) were taken then the induction protocol was conducted for both groups; after that, the treatment protocol was started for the treatment group and lasted for 3 consecutive days.

Phase 3

The same measurements for both groups were repeated 24 hrs. post-induction at the same hour.

Phase 4

The same measurements were repeated for both groups 72 hrs. post-induction after completion of treatment protocol at the same hour.



Instructions were given to the subjects of both groups

- All subjects were requested to maintain the usual activity pattern of their lifestyle throughout the study.
- All subjects were asked not to do any dietary habits changing during the experimental period.
- All subjects were requested not to take part in any unaccustomed exercise except that descriped in the present study.
- All subjects were requested not to provide any self-treatment to alleviate any DOMS they may experience for the duration of the study.
- All subjects were requested to wear loose-fit clothing to all sessions.
- All subjects completed the same eccentric protocol for inducing DOMS in the non-dominant elbow flexor muscles.

On the day of the induction protocol prior to the induction, subjects of both groups completed baseline measurements, including serum creatine kinase level (CK) through blood sampling. Subjects went to the laboratory to obtain baseline measurements of the CK activities after at least 8 hrs. of overnight fasting. By using the typical venipuncture method, about 8 mL of blood was obtained from the antecubital vein. Blood samples were taken into untreated serum collecting tubes, left to clot approximately 15 minutes (at room temperature), and then centrifuged for five min at 3,000 rpm (**Rodrigues et al., 2010**)

Level of Pain was measured by a Visual Analog Scale (VAS). The VAS ranges from 0 (no pain) on the left side to 10 (extremely painful) on the right side. (Worst pain imaginable). Subjects were asked to mark on the line the point representing the pain they felt on the exercised muscles. The distance in centimeters from the zero extremity to the mark made by the subject provided levels of pain intensity. (**Williamson and Hoggart, 2005)**

The lateral epicondyle was selected as the point of reference for the goniometer, with the acromion process serving as the reference point for the stationary arm. Because of their convenient placement on the elbow as well as the shoulder, those two bony landmarks are universally accepted as the standard for measuring elbow ROM. Goniometer's movable arm is pointed in the direction of the ulnar styloid process. When the value of extension is greater than zero, flexion occurs, and when it is less than zero, hyperextension occurs (Morrey and Sanchez-Sotelo, 2008)

A chair without armrests was provided for each participant. When the wrist was at a neutral position, we evaluated the elbow flexion and extension ROM. Three measures were taken in each position, with the examiner making sure to prompt the participants to reach full extension and flexion.

All baseline measurements were repeated at multiple time points, including baseline, 24 hrs, and 72 hrs. post induction of muscle soreness.

After taking the baseline measurements, subjects of both groups underwent the eccentric exercise protocol to induce DOMS in the elbow flexor muscles of the non-dominant arm. A week following the exercise weight was determined, the same arm was used to perform the DOMS-inducing exercise session. Muscle injury on a large scale can be induced with this method.

Muscle soreness induction: While seated, the individual's non-dominant elbow was supported on the ipsilateral knee. It took the individual around three to five seconds to lower the weight to complete elbow extension.

The investigator returned the weight to a starting position of full elbow flexion to emphasize the eccentric contraction. The investigator verbally encouraged the subjects to help maintain maximal effort throughout the protocol.

The exercise involved 3 sets with twelve repetitions for each set (36 overall). The rest among every set will be 60 seconds.

The process was repeated until completion of repetition or control over the speed of descent could no longer be obtained. The same measurements were repeated after the induction by 24 and 72 hours.

The treatment protocol was as follows

Airflow cryotherapy was done to all the subjects in the study group by using a CRYOFLOW ICE-CT skin cooling system (Pasweg 6A, 3740 Bilzen, Belgium). All the subjects in the study group received locally applied airflow cryotherapy treatment sessions per day for 4 consecutive days, immediately, at 24 hrs., at 48 hrs., and at 72 hrs post-induction. Each session lasted for 10 minutes. The biceps brachii of the non-dominant arm was cooled to 12°C by blowing cold air via a 15 mm tip at a distance of 5 cm from the skin on the exercising arm. For cryotherapy to be effective, skin temperature was monitored using an infrared feedback device. While lying down, the participant's biceps muscle belly was subjected to cryotherapy. Elsayed et al 2015 .'s study was the basis for our selection of these parameters.

Statistical analysis

To compare subject characteristics among groups, an unpaired t-test was carried out. The gender distribution of different groups were compared using the chi-squared test. The Shapiro-Wilk test and Levene's test were utilized to examine the equality of variances and verify that the data followed a normal distribution. Mean values of serum CK, elbow flexion, and extension ROM were analysed using mixed MANOVA to examine the effect of time (before versus post) and the impact of treatment (among groups), in addition to the interaction between time and also treatment. When conducting multiple post hoc tests, the Bonferroni adjustment was used. When comparing VAS across groups, an unpaired t-test was used, while a paired t-test was used to compare VAS at post I and post II within each group. SPSS for Windows, Version 25 was used for statistical analysis. SPSS is a statistical tool for the social sciences. All statistical tests were conducted with a p-value of 0.05 as the threshold for significance.

Results

Subject characteristics

30 healthy male patients took part in this study. Patients characteristics are shown in table 1. There was no substantial difference in characteristics of patients among groups ($p > 0.05$).

Table (1) Basic characteristics of participants.

	Group A	**Group B**			
	Mean ± SD	**Mean ± SD**	**MD**	**t- value**	**p-value**
Age (years)	28.2 ± 5.96	28.06 ± 6.01	0.14	0.06	0.95
Weight (kg)	78.06 ± 9.37	74.46 ± 7.17	3.6	1.18	0.24
Height (cm)	179.46 ± 8.03	178.33 ± 7.02	1.13	0.41	0.68
BMI (kg/m²)	24.26 ± 2.83	23.48 ± 2.68	0.78	0.77	0.44

SD, standard deviation; MD, mean difference; p-value, Probability value

Impact of treatment on serum CK, elbow flexion, and extension ROM

Mixed MANOVA revealed a substantial interaction of treatment as well as time ($F = 198.33$, $p = 0.001$, Partial Eta Squared = 0.98). There was a substantial main impact of time ($F = 1528.81$, $p = 0.001$, Partial Eta Squared = 0.99). There was a substantial main impact of treatment ($F = 724.24$, $p = 0.001$, Partial Eta Squared = 0.98).

Within group comparison

There was a substantial increase in serum CK at post I as well as post II compared to pre-induction of muscle soreness in both groups ($p < 0.001$). There was a substantial decline in serum CK at post II compared to post I in both groups ($p < 0.001$).

There was a substantial decrease in elbow flexion and extension ROM at post I compared to pre-induction of muscle soreness in both groups ($p < 0.001$). There was a substantial improvement in elbow flexion as well as extension ROM at post II compared to post I in both groups ($p < 0.001$). There was a substantial decline in elbow extension ROM at post II compared to pre-induction of muscle soreness in both groups ($p < 0.001$).

There was no significant difference in elbow flexion ROM between pre-induction of muscle soreness and post II in the study group (p = 0.37), while there was a substantial decline in elbow flexion ROM at post II compared to pre-induction of muscle soreness in the control group (p < 0.001). (Table 2).

There was a substantial decline in VAS at post II compared to post I in both groups (p < 0.001). The percentage of change of VAS in the study group was 61.01%, while that of the control group was 31.26%. (Table 3).

Between-group comparison

There was a substantial decline in serum CK of study group at post I as well as post II compared to that of control group (p < 0.001). There was a significant increase in elbow flexion and extension ROM of study group at post I as well as post II compared to that of control group (p < 0.001). (Table 2).

There was a substantial decline in VAS of the study group at post I as well as post II compared to that of the control group (p < 0.001). (Table 3).

Table (2) Mean serum CK, elbow flexion, and extension ROM in study and control groups at pre-treatment, post I and post II.

	Pre treatment	**Post I**	**Post II**	**p-value**		
	mean ± SD	**mean ± SD**	**mean ± SD**	**Pre vs post I**	**Pre vs post II**	**Post II vs post I**
Serum CK (U/L)						
Study group	84.86 ± 7.39	168.6 ± 7.58	114.4 ± 12.11	0.009	0.001	0.001
Control group	85.26 ± 7.06	295 ± 10.65	190.06 ± 10.4	0.001	0.001	0.001
MD	-0.4	-126.4	-75.66			
	p = 0.88	p = 0.001	p = 0.001			
Elbow flexion ROM (degrees)						
Study group	147.26± 2.81	130.93 ± 2.52	145.4± 2.64	0.001	0.37	0.001
Control group	147.46 ± 3.96	126.46 ± 4.15	135.4 ± 3.85	0.001	0.001	0.001
MD	-0.2	4.47	10			
	p = 0.87	p = 0.001	p = 0.001			
Elbow extension ROM (degrees)						
Study group	-11 ± 1.31	1.33 ± 0.97	-7.13 ± 1.3	0.009	0.001	0.001
Control group	-11.6 ± 1.29	9 ± 1	0.93 ± 1.09	0.001	0.001	0.001
MD	0.6	-7.67	-8.06			
	p = 0.21	p = 0.001	p = 0.001			

SD, standard deviation; MD. Mean difference; p value, Probability value

Table (3) Mean VAS at post I and post II of study and control groups:

	Post I	**Post II**			
	Mean ±SD	**Mean ±SD**	**MD**	**% of change**	**p value**
VAS					
Study group	5.13 ± 1.06	2 ± 0.92	3.13	61.01	0.001
Control group	7.07 ± 0.96	4.86 ± 0.91	2.21	31.26	0.001
MD	-1.94	-2.86			
	p = 0.001	p = 0.001			

SD, Standard deviation; MD, Mean difference; p value, Probability value

Discussion

cryotherapy is one of the most well-known and extensively spread methods to treat pain as well as swelling in an easily accessible and great effect fashion. Research on the effects of cold treatment to date has shown positive outcomes. Cryotherapy has shown promising benefits at temperatures between 10 and 15 ° C. when given locally for 10 to 15 minutes, but there is no consensus on the optimal duration of treatment because extended exposure can inhibit metabolism and perhaps induce tissue damage (Bleakley et al., 2004).

The purpose of airflow cryotherapy is to remove thermal energy from the treated area by convection by continually exposing the area to cold air. It is now widely used as it causes a more significant decline in skin temperature lower than other cryotherapy techniques. It reduces the blood flow and capillary permeability by causing vasoconstriction of arterioles**. (Yeter K.andMagfiret K.2019) (Elsayed et al., 2015)**

The findings of this study suggested that continuous Airflow cryotherapy effectively decreased serum Creatine Kinase level (CK) and pain in DOMS in healthy subjects. Also, it is effective in increasing elbow flexion and extension ROM.
These results agree with **Salah Eldin et al., 2015** who stated that cryoflow therapy, throughout its both mechanical as well as thermal impacts, is more efficient than regular cryogel packs in reducing the symptoms linked with DOMS.
Similarly, a systematic review by **Catriona Rose et al., 2017** indicated that cold application accelerates muscle recovery by dampening cytokine response, CK, and cortisol concentrations, which may suggest less secondary tissue damage in the regeneration process.

In the same way, a meta-analysis by **Jonathan Leeder et al., 2012**, postulated that cold application effectively reduced CK efflux in the blood following-exercise from a sample of 22 extracted information points.
In accordance with our study, a meta-analysis by **Wang et al., 2021** included 32 studies that included 1,098 people. The meta-analysis demonstrated that cold therapy effectively decreased pain related to DOMS during the first 24 hours after exercise.

Previous study suggests that this is because cryotherapy decreases perceived pain by decreasing the osmotic pressure of exudates (metabolites produced from inflammation), that in turn activates the afferent terminals of nerve branches. Cold application has been hypothesized to reduce blood circulation to muscle. The lower arterial flow could be the result of a change in sympathetic nervous system activity triggered by stimulation of the heat nociceptors. It is hypothesized that cold's physiological impact is achieved, at least in part, by temperature-induced declines in microvascular blood flow near the injury site, hence lowering edema and preventing the induction of inflammatory processes (Oakley et al., 2013 & Chesterton et al., 2007).

Emma et al 2022 .'s systematic review It was shown that 24 hours following high-intensity exercise, ice immersion helped improve muscle power, muscle soreness, creatine kinase (CK), and precieved recoverey. However, it only had a beneficial effect on muscle strength when performed 24 hours after eccentric activity. They added that dose-response connections appeared for favorably affecting endurance performance and lowering serum CK, suggesting that cold immersion may be more effective if utilized for shorter durations with lower temperatures following high-intensity exercise

The considerable variability of CK measurements may be due to their sensitivity to variations in blood flow. In this study, we show that differences in myofibrillar protein-coding genotypes affect the phenotypic reaction to muscle injury after eccentric exercise, as measured by CK and functional loss of strength. As a result, similar participants can have widely varying CK responses to intense exercise (age, sex, athletic status).

However, it should be emphasised that the exercise training program for generating DOMS has not been standardised so far, and that the intervention time as well as temperature of cold administration in each trial included were not quite the same.

Therefore, cryotherapy is a simple and inexpensive treatment that can be led and advised as a home program to aid in the progression of rehabilitation, preventing the persistence of pain, edoema, inflammation, and consequences of DOMS. This means that the goals of ice (continuous air flow cryotherapy) are functional restoration and the restoration of pre-injury levels of everyday activities.

Although the presence of different studies on the effectiveness of cold application, there is still a lack of evidence supporting the use of cold application mainly due to a lack of guided parameters for the application; this gives attention to the need for further research studying the effectiveness of different parameters of application with concern to time interaction.

Conclusion

The continuous airflow cryotherapy is a rehabilitative technique that aids recovery by preventing the complications of DOMS, chronic pain, swelling, as well as inflammation. So, the goals of continuous airflow cryotherapy are to restore function and enable patients to resume their pre-injury level of activities of daily living.

Clinical implementations
Using continuous airflow cryotherapy enhances improvements and speeds recovery from DOMS.

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