Efficacy of cryoflow therapy in induced muscle soreness: a randomized trial

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Background
An individual experiencing delayed-onset muscle soreness notices pain and aching within the affected muscles, decreased range of motion, and loss in muscle strength beginning 12–24 h after exercise, peaking between 48 and 72 h, and subsiding within 5–7 days after exercise. The aim of this study was to investigate the effect of locally applied cryoflow therapy on pain and function in induced muscle soreness of nondominant elbow flexors.

Participants and methods
Sixty healthy individuals participated in this study. They were divided randomly into two groups, 30 in each group. Pre-exercise measures were recorded for pressure pain threshold using a pressure algometer and level of limitation using Patient-Rated Elbow Evaluation. Participants performed free-weight curl exercises until fatigue using a 10-lb dumbbell at a tempo of 1 s for the concentric phase and 3 s for the eccentric phase to induce muscle soreness. Group A underwent cryoflow therapy administered immediately after exercise using a ShockMaster ICE-CT cryotherapy device at 12°C for 10 min once a day for 4 days. Group B underwent cold treatment using a flexible gel pack for 10 min once a day for 4 days. Dependent variables were assessed at 0, 24, 48, and 72 h after exercise.

Results
Statistically significant differences were found between both groups for pain using pressure threshold and pain level of the Patient-Rated Elbow Evaluation scale at 48 and 72 h (P = 0.01, 0.002, and 0.0006, 0.0001, respectively); for the functional scale, statistically significant differences were found only at 72 h (P = 0.0001).

Conclusion
Cryoflow therapy was superior in overcoming delayed-onset muscle soreness than the use of a cryogel pack in case of induced muscle soreness.

Keywords:
cryoflow therapy, cryotherapy, delayed-onset muscle soreness, eccentric exercise

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Introduction

Cryotherapy is the use of cold, applied locally or generally, through various methods to lower the temperature of the skin and subcutaneous tissues [1]. Cryotherapy leads to reductions in cellular, lymphatic, and capillary permeability because of vasoconstriction and is also considered to reduce the inflammatory response of damaged muscle, edema, and pain perception [2]. Cryotherapy includes whole-body cryotherapy, cold-water immersion, ice or cold gel pack application, ice massage, or any other local or general application of cold for therapeutic purposes [3].

Cryotherapy reduces the temperature of the tissues, which produces vasoconstriction and leads to a decrease in the metabolic rate of the tissues. These physiological effects result in control of inflammation and edema, which leads to reductions in pain and spasm [4]. Cryotherapy treats the muscle damage caused by intensive exercise. Cryotherapy not only stimulates muscle cell activity but also helps repair the damage [5].

High-intensity exercise including predominantly eccentric activity, unaccustomed activity, and exercise of long duration and/or high intensity has been shown to induce an inflammatory response [6]. In response to stress and/or muscle damage induced by exercise, muscle fibers and associated cells release signaling molecules (cytokines) into the circulation, which subsequently influence the recruitment of inflammatory cells. This process initiates a positive feedback mechanism characteristic of the inflammatory response, resulting in further upregulation of signaling molecules and activation/infiltration of inflammatory cells into muscle

fibers that have been stressed or damaged during the exercise bout [7].

The inflammatory response is necessary for the resolution of any structural damage that may have occurred, and may be important for the adaptive response of skeletal muscle to exercise [8]. However, if prolonged or excessive, the inflammatory response can cause secondary damage to surrounding cells and contribute toward oxidative stress of the muscle fibers, thereby compounding the stress/damage that the muscle fibers experience. For this reason, the inflammatory response has been implicated in delayed-onset muscle soreness (DOMS), edema, reduced performance capacity, and fatigue commonly experienced following various forms of strenuous exercise [9].

A considerable amount of research has been carried out on the etiology and treatment of DOMS. Some of the therapeutic modalities that have been used to treat DOMS include stretching exercises, superficial heat (hydrocollator packs), therapeutic ultrasound, microcurrent electrical stimulation, iontophoresis, phonophoresis, transcutaneous electrical stimulation, hyperbaric oxygen therapy, low-intensity laser therapy, therapeutic massage, ice, and ice massage [10–13]. It has been claimed that the use of cryotherapy, or ice massage, in treating this muscle damage delays the onset of muscle pain and soreness [14]. Moreover, cryotherapy aids in recovery between training sessions and reduces exercise-associated DOMS [15].

Cryoflow therapy is a relatively new modality in the physical therapy field that ensures a constant temperature on the treatment area. It cools down surrounding air for cryotherapy, which is suggested to be used for local anesthesia (analgesia) for pain relief and rehabilitation, motor effects to improve mobility, and for anti-inflammation by a combination of cold and compression with powerful cold airflow [16]. To the best of our knowledge, there was no report of previous studies that have compared its effects with regular forms of cryotherapy. Thus, the aim of this study was to investigate the effect of locally applied cryoflow therapy on muscle pain and function in case of induced muscle soreness of the elbow flexors.

Participants and methods

This study was carried out in the Physiotherapy Outclinic of the Military Production Specialized Medical Center in Helwan from July to October 2014 to investigate the effect of locally applied shock cryotherapy on pain in case of induced muscle soreness of the nondominant elbow flexors.

Participants

A randomized trial with repeated measures was used to investigate the effect of locally applied cryoflow therapy on pain and function in case of induced muscle soreness on nondominant elbow flexors using a pressure algometer and the Patient-Rated Elbow Evaluation (PREE) scale.

Sixty healthy men participated in this study after approval of Ethical Committee of the Faculty of Physical Therapy, Cairo University, and all participants provided written informed consent.

The participants were assigned randomly to two groups of equal numbers by rolling of a dice: group A (odd number) and group B (even number). Random permuted size 4 blocks were used to achieve a balance in the sample sizes between two groups. The assignment to groups was carried out by a therapist who was blinded to the research protocol. Each group included 30 participants. Participants were included if their age ranged from 25 to 35 years, if they had no history of upper arm or elbow injury, and had no current arm pain/discomfort before participation in the study. The exclusion criteria for participants were hypersensitivity to cold application, diabetes, recent shoulder or elbow operations, open wounds and ulcers, using of anti-inflammatory drugs or alternate treatment, thromboembolic changes and inflammation in the venous system, or Raynaud's disease (Fig. 1).

Instrumentation

Assessment instrumentation

Assessment of pain using pressure algometry: A hand-held pressure algometer (Fabrication Enterprises, White Plains, New York, USA) was used to measure perceived pain by pressure in kg/cm^2. The interexaminer reliability of the pressure algometer has been reported to be good, with a mean intraclass correlation coefficient (ICC) of 0.75. Intraexaminer reproducibility was excellent (mean ICC = 0.84). The mean interexaminer coefficient of variation was 18.7%, whereas the mean coefficient of repeatability was 1.60 kg/cm^2. The validity of manual algometry presented by Pearson's correlation coefficient was 0.9 (95% confidence interval = 0.8–1.0 and $P < 0.001$) [17–19].

Assessment of pain and functional disability using the PREE scale: The PREE is a 20-item questionnaire designed to measure elbow pain and disability level in activities of daily living. The PREE enables patients to rate their levels of elbow pain and disability from 0 to 10 and consists of two subscales:

(a) Pain subscale (0 = no pain, 10 = worst ever) with pain – five items and

(b) Function subscale (0 = no difficulty, 10 = unable to do) with specific activities – 11 items, and usual activities – four items.

In addition to the individual subscale scores, a total score could be computed on a scale of 100 (0 = no disability), where pain and functional problems were weighted equally. The PREE scale has been found to have a high internal consistency of 0.95; the PREE was found to show excellent test–retest reliability (ICC = 0.95). *Construct validity*: It was found that PREE showed moderate to high correlations with the patient-reported form of the American Shoulder and Elbow Surgeons questionnaire elbow form (Spearman's r = 0.92) and the Disabilities of the Arm, Shoulder and Hand questionnaire (Spearman's r = 0.68) [20–22].

Treatment instrumentation

(1) *Cryoflow therapy*: GymnaUniphy N.V., Belgium. By continuous measurement of the skin temperature using an infrared sensor, airflow was adjusted automatically to achieve and maintain the desired temperature. This was used for the treatment of group A.
(2) A flexible gel pack was used for the treatment of group B.

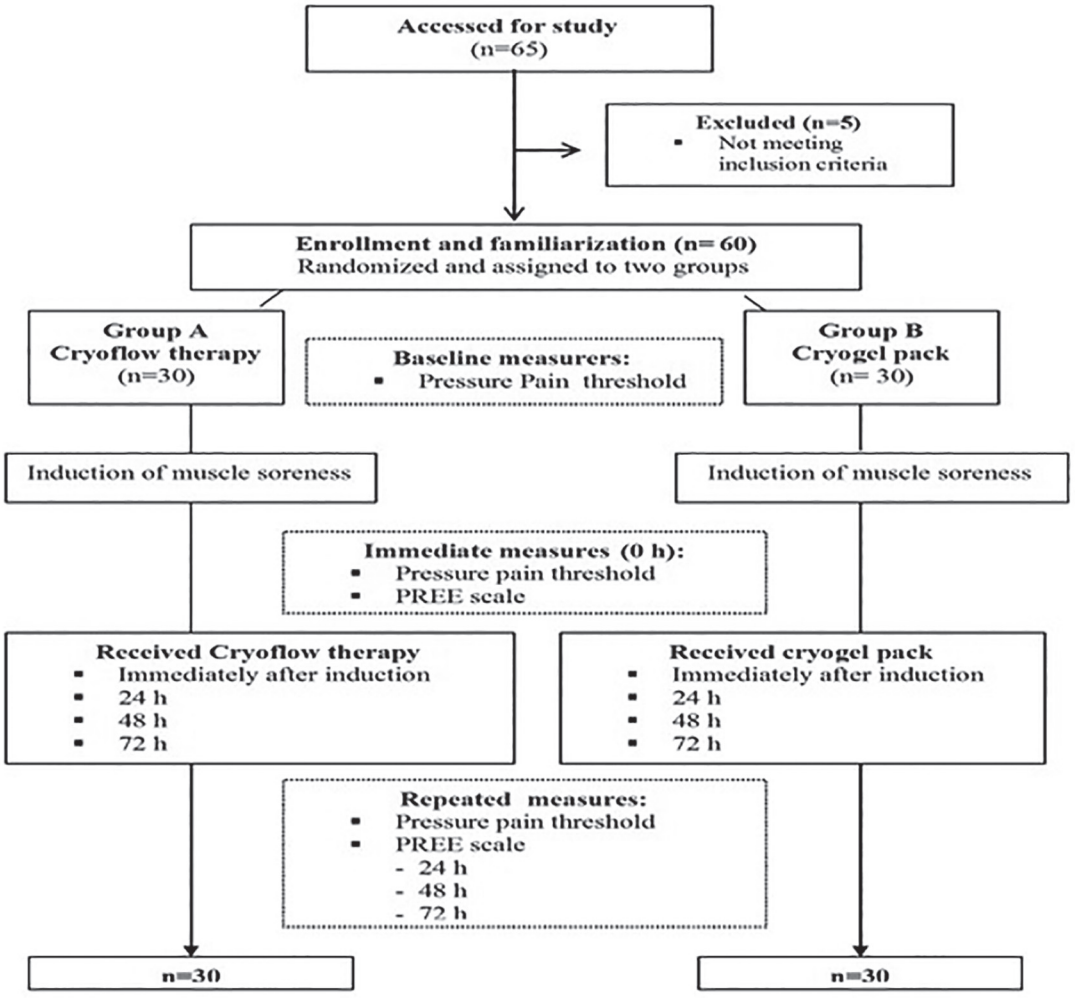
Procedure

This study included four phases: pre-exercise measurements for pain using a pressure algometer and function using the PREE scale, induction of DOMS, cryotherapy treatments, and post-treatment measurements.

Pre-exercise measurements

Pressure pain threshold was determined using a calibrated mechanical Algometer at a constant force rate of 1 kg cm^2/s at the biceps distal musculotendinous junction. The pressure stimulus was applied at 25% of the distance from the cubital fossa to the greater tuberosity

Figure 1



Flow chart of the study. 0 h: immediately after exercise, 24 h: 24 h after exercise, 48 h: 48 h after exercise, 72 h: 72 h after exercise.

of the humerus. The amount of pressure applied was increased until the participant [17–19,21,22].

Induction of delayed-onset muscle soreness

Muscle soreness was induced in the nondominant arm using concentric and eccentric dumbbell curl exercises. Participants were sitting with the nondominant arm positioned in front of the body with both the arm and the forearm completely supported with shoulder flexion to an approximately right angle with the forearm fully supinated. Participants were instructed to perform elbow flexion/extension of their nondominant arm using a 10-lb dumbbell while sitting until they reached the point of fatigue (Fig. 2). Fatigue was considered the state of physiological inability of a muscle to produce a contraction even though the muscle was receiving stimuli. The eccentric portion of the exercise was emphasized by instructing the participant to complete each curl at a rate of 1 s for the concentric phase and 3 s for the eccentric phase [22,23].

Treatment protocols

Group A: Group A underwent cryoflow therapy administered immediately after exercise using a ShockMaster ICE-CT cryotherapy device at 12°C for 10 min with a 15 mm nozzle size. One session was performed daily for 4 days at the bicep region (Fig. 3).

Group B underwent cryotherapy using a cryogel pack (ColPac, Chattanooga, UK), for 10 min once a day for 4 days.

We asked the participant to refrain from any form of strenuous physical activity and to avoid all medications, including anti-inflammatory agents, as well as any self-massage on the arm for the duration of the study.

Postexercise measurements

Post-treatment measurements for pain and disability were performed using a calibrated mechanical Algometer and the PREE scale according to the procedures outlined for pretreatment measurements. The participants completed the measurements of pain and disability immediately after exercise 0, 24, 48, and 72 h later using the elbow pain and disability scale and the PREE; pain and function limitation levels were recorded [20].

Sample-size determination

On the basis of a pilot study, the primary clinical outcome of DOMS (i.e. pressure pain threshold) was determined to obtain a power of 0.8 at an α level of 0.05 with an effect size of 0.84; total sample-size estimation would be ~20 participants per group using G*Power 3.1 software (Institut für Experimentelle Psychologie: Heinrich-Heine-Universität Universitätsstraße, Düsseldorf, Germany), and to account for dropout rates, the sample size was increased to 30. Only male participants were recruited to avoid sex differences [13].

Outcome measures

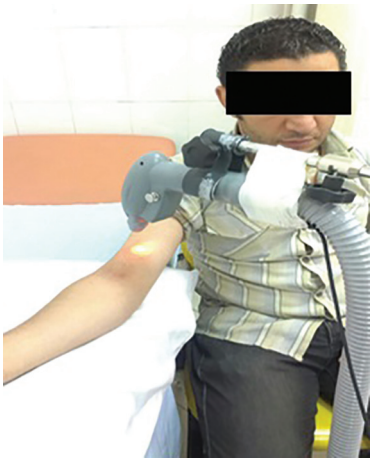
The primary outcome measure for determining the effect of cryoflow was pressure pain threshold using a pressure algometer. The pressure algometer has been shown to be reliable and valid for measuring the pain threshold in case of DOMS [17–19,24,25].

The other outcome measure that we used to compare the effects of cryoflow therapy and cryogel pack was the PREE scale. PREE represents a reliable and valid

Figure 2

Induction of muscle soreness.

Figure 3



Application of cryoflow therapy.

instrument to evaluate subjective outcomes in patients with elbow pathology [20,21].

Data analysis and statistical design

All statistical measures were carried out using the Statistical Package for Social Studies (SPSS) version 19 for Windows (Armonk, NY: IBM Corp). Descriptive statistics and a *t*-test were used for comparison of the mean age between both groups. Mixed analysis of variance was used to compare the pretreatment and post-treatment mean values of pressure pain threshold in each group and between both groups. The Mann–Whitney *U*-test was used for comparison of post-treatment median values of PREE between both groups. The Wilcoxon signed-ranks test was used for comparison of post-treatment median values of PREE in each group. The level of significance for all statistical tests was set at *P*-value less than 0.05.

Results

Participants' characteristics

Group A: Thirty healthy male participants were included in this group and they received cryoflow therapy (Table 1 and Fig. 1).

Group B: Thirty healthy male participants were included in this group and they received a cryogel pack (Table 1 and Fig. 1).

Comparison of the demographic data of 60 participants in both groups showed that there was no significance difference between both groups in the mean age, height, weight, smoking, and marital status values ($P = 0.85, 0.95, 0.67, 0.8$, and 0.6, respectively) (Table 1).

Effect of cryotherapy on pressure pain threshold

Group A

There was a significant decrease in pressure pain threshold at 0, 24, 48, and 72 h measurements compared with before treatment ($P = 0.0001$). The mean difference between pretreatment and 24 h measurements was 0.65 kg/cm^2/s and the percent of change was 38.87%. The mean difference in pressure pain threshold between pretreatment and 48 h measurement was 0.37 kg/cm^2/s and the percent of change was 22.69%. The mean difference between pretreatment and 72 h measurements was 0.15 kg/cm^2/s and the percent of change was 9.2% (Table 2 and Fig. 4a).

Group B

There was a significant decrease in pressure pain threshold at 24, 48, and 72 h measurements compared with before treatment ($P = 0.0001$). The mean difference in pressure pain threshold between pretreatment and 48 h measurement was 0.59 kg/cm^2/s and the percent of change was 35.7%. The mean difference between pretreatment and 72 h measurements was 0.47 kg/cm^2/s and the percent of change was 28.48% (Table 2 and Fig. 4a).

Comparison between both groups

Multiple pairwise comparisons showed that there was no significant difference in the mean values of pressure pain threshold between both groups at pretreatment, 0, and 24 h after treatment ($P > 0.05$). However, there was a significant increase in the mean value of pressure pain threshold at 48 and 72 h in the study group compared with the control group ($P = 0.01$ and 0.002 respectively) (Table 2). There was a significant interaction between time and group effect ($P = 0.0001$).

Effect of cryotherapy on the pain level score of the Patient-Rated Elbow Evaluation scale

There was no significant difference in the median values of the pain score between both groups at 0 and 24 h after treatment ($P > 0.05$). However, there was a significant decrease in the median value of pain at 48 and 72 h in group A compared with group B ($P = 0.006$ and 0.0001, respectively) (Tables 3–5 and Fig. 4b).

Table 1 Demographic characteristics of participants

Group	Experimental group ($n = 30$) (mean ± SD)	Control group ($n = 30$) (mean ± SD)	*P*-value	Significance
Age (years)	29.46 ± 3.27	29.26 ± 2.76	0.85	NS
Height (cm)	168.8 ± 2.95	169.25 ± 2.2	0.95	NS
Weight (kg)	66.4 ± 3.55	67.45 ± 2.5	0.67	NS
Smoking [*n* (%)]				
Yes	16 (53)	17 (56)	0.8	NS
No	14 (47)	13 (44)		
Marital status [*n* (%)]				
Single	18 (60)	16 (53)	0.6	NS
Married	12 (40)	14 (47)		

Table 2 Mean values of pressure pain threshold before treatment, and 0, 24, 48, and 72 h after treatment of group A and group B

	Pressure pain threshold (kg/cm²/s)				
	$\bar{x}$ ± SD				
	Pretreatment	0 h	24 h	48 h	72 h
Group A	1.63 ± 0.27	1.46 ± 0.26	0.98 ± 0.22	1.26 ± 0.24	1.48 ± 0.28
Group B	1.65 ± 0.27	1.45 ± 0.24	0.9 ± 0.18	1.06 ± 0.19	1.18 ± 0.2
Mixed ANOVA					
Within-group comparison (Bonferroni correction)					
F = 358.29	P = 0.0001				
Multiple pairwise comparison (Bonferroni correction)					
	MD	% of change	P-value	Significance	
Group A					
Pretreatments vs. 0 h	0.17	10.42	0.0001	S	
Pretreatments vs. 24 h	0.65	38.87	0.0001	S	
Pretreatments vs. 48 h	0.37	22.69	0.0001	S	
Pretreatments vs. 72 h	0.15	9.2	0.0001	S	
0 vs. 24 h	0.48	32.87	0.0001	S	
0 vs. 48 h	0.2	13.69	0.0001	S	
0 vs. 72 h	−0.02	1.36	1	NS	
24 vs. 48 h	−0.28	28.57	0.0001	S	
24 vs. 72 h	−0.5	51.02	0.0001	S	
48 vs. 72 h	−0.22	17.46	0.0001	S	
Group B					
Pretreatments vs. 0 h	0.2	12.12	0.0001	S	
Pretreatments vs. 24 h	0.75	45.45	0.0001	S	
Pretreatments vs. 48 h	0.59	35.7	0.0001	S	
Pretreatments vs. 72 h	0.47	28.48	0.0001	S	
0 vs. 24 h	0.55	37.93	0.0001	S	
0 vs. 48 h	0.39	26.89	0.0001	S	
0 vs. 72 h	0.27	18.62	0.0001	S	
24 vs. 48 h	−0.16	17.77	0.0001	S	
24 vs. 72 h	−0.28	31.11	0.0001	S	
48 vs. 72 h	−0.12	11.32	0.0001	S	
Between-group comparison					
F = 1.92	P = 0.17				
Multiple pairwise comparison (Bonferroni correction)					
	MD	P-value	Significance		
A vs. B					
Pretreatment	−0.02	0.84	NS		
0 h	0.01	0.88	NS		
24 h	0.08	0.3	NS		
48 h	0.2	0.01	S		
72 h	0.3	0.002	S		
Interaction effect (time×group)					
F = 22.93	P = 0.0001				

NOVA, analysis of variance; MD, mean difference; NS, nonsignificant; S, significant.

Table 3 Friedman test for comparison of median values of pain at 0, 24, 48, and 72 h after treatment of group A

	Wilcoxon signed-ranks test		
	Z-value	P-value	Significance
0 vs. 24 h	3.41	0.001	S
0 vs. 48 h	3.41	0.001	S
0 vs. 72 h	0.09	0.92	NS
24 vs. 48 h	3.41	0.001	S
24 vs. 72 h	3.41	0.001	S
48 vs. 72 h	3.41	0.001	S

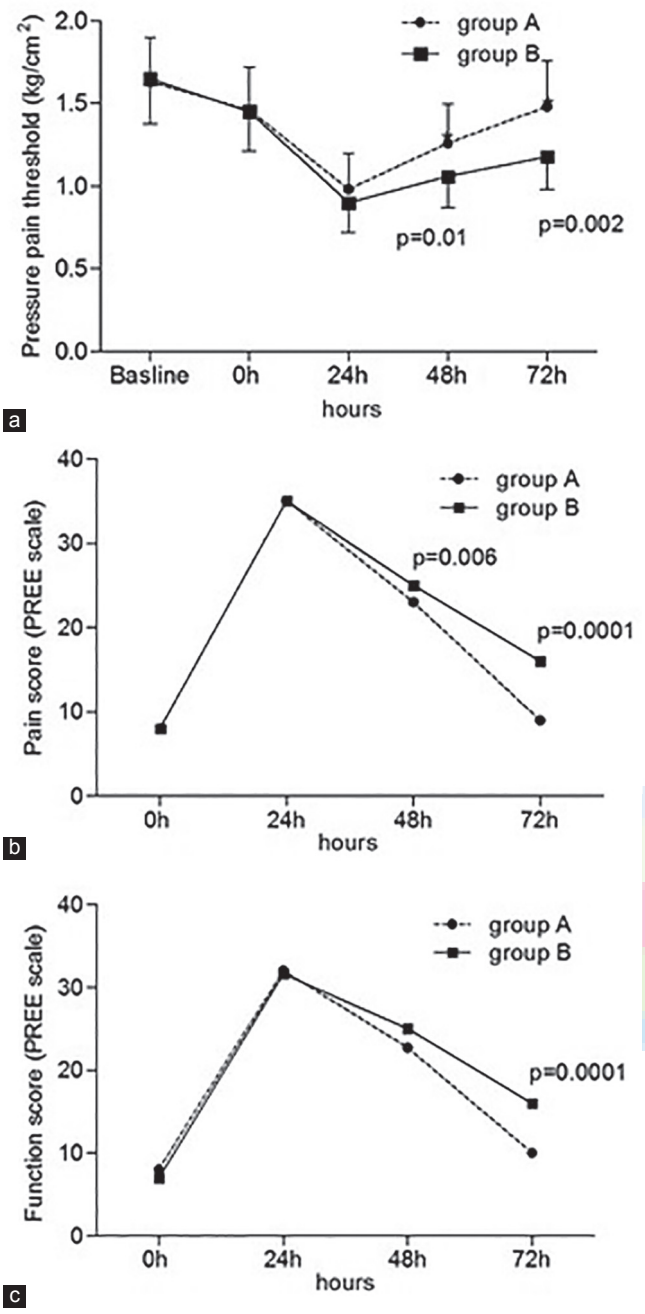
NS, nonsignificant; S, significant.

Table 4 Friedman test for comparison of median values of pain at 0, 24, 48, and 72 h after treatment of group B

	Wilcoxon signed-ranks test		
	Z-value	P-value	Significance
0 vs. 24 h	3.41	0.001	S
0 vs. 48 h	3.41	0.001	S
0 vs. 72 h	3.29	0.001	S
24 vs. 48 h	3.41	0.001	S
24 vs. 72 h	3.41	0.001	S
48 vs. 72 h	3.41	0.001	S

NS, nonsignificant; S, significant.

Figure 4



(a) Mean values of pain pressure threshold of both groups throughout the experimental period. (b) Median values of the pain score in Patient-Rated Elbow Evaluation (PREE) of both groups throughout the experimental period. (c) Median values of the function score in PREE of both groups throughout the experimental period.

Table 5 Mann–Whitney *U*-test for comparison between the median values of pain at 0, 24, 48, and 72 h after treatment of groups A and B

	Pain		*U*-value	*P*-value	Significance
	Median				
	Group A	Group B			
0 h	8	8	102	0.65	NS
24 h	35	35	94.5	0.45	NS
48 h	23	25	47	0.006	S
72 h	9	16	2.5	0.0001	S

NS, nonsignificant; S, significant.

Table 6 Friedman test for comparison of median values of function at 0, 24, 48, and 72 h after treatment of group A

	Wilcoxon signed-ranks test		
	Z-value	*P*-value	Significance
0 vs. 24 h	3.4	0.001	S
0 vs. 48 h	3.4	0.001	S
0 vs. 72 h	2.86	0.004	S
24 vs. 48 h	3.41	0.001	S
24 vs. 72 h	3.41	0.001	S
48 vs. 72 h	3.4	0.001	S

S, significant.

Table 7 Friedman test for comparison of median values of pain at 0, 24, 48, and 72 h after treatment of group B

	Wilcoxon signed-ranks test		
	Z-value	*P*-value	Significance
0 vs. 24 h	3.41	0.001	S
0 vs. 48 h	3.40	0.001	S
0 vs. 72 h	3.42	0.001	S
24 vs. 48 h	3.41	0.001	S
24 vs. 72 h	3.4	0.001	S
48 vs. 72 h	3.41	0.001	S

S, significant.

Table 8 Mann–Whitney *U*-test for comparison between the median values of function at 0, 24, 48, and 72 h after treatment of groups A and B

	Pain		*U*-value	*P*-value	Significance
	Median				
	Group A	Group B			
0 h	8	7	93.5	0.42	NS
24 h	32	31.66	91	0.36	NS
48 h	22.7	25	78.5	0.15	NS
72 h	10	16	23	0.0001	S

NS, nonsignificant; S, significant.

Effect of cryotherapy on the function level score of the Patient-Rated Elbow Evaluation scale

There was no significant difference in the median values of function between both groups at 0, 24, and 48 h after treatment ($P > 0.05$). However, there was a significant decrease in the median value of function at 72 h in group A compared with group B ($P = 0.0001$) (Tables 6–8 and Fig. 4c).

Discussion

The aim of this study was to investigate the effect of cryoflow therapy on pain and function limitations in case of induced muscle soreness of nondominant elbow flexors. Sixty healthy individuals (male) were participated in this study.

One of the limitations of this study was that the use of cryoflow therapy produced a significant decrease in pressure pain threshold and the PREE scale (for both pain and function levels) in case of induced muscle soreness.

The exercise used in this study produced a significant decrease in pressure pain threshold, especially within 24 h, and increase of the values of PREE scale (both pain and function sections) especially at 48 h. The finding was consistent with those in the literature [6–8]. Eccentric exercise induces a comparatively greater degree of mechanical stress and subsequent muscle damage compared with concentrically or isometrically biased exercise. This is because of the combination of cross-bridges producing force while lengthening, greater force per muscle fiber, and the large degree of force contribution by passive tissues [26]. DOMS frequently occurs after unaccustomed exercise, particularly if the exercise involves a large amount of eccentric (muscle lengthening) contractions. The intensity of discomfort and soreness associated with DOMS increases within the first 24 h, peaks between 24 and 72 h, before subsiding and eventually disappearing 5–7 days after the exercise [8].

The results of the current study showed that there was a significant increase in the mean value of pressure pain threshold at 48 and 72 h in group A in comparison with group B, which suggests that cryoflow therapy is more effective than a cryogel pack in reducing pain.

Also, there was a significant decrease in the median values of function scores of PREE between both groups at 72 h in group A compared with group B and a significant decrease in the median values pain scores of PREE at 48 and 72 h, which suggests that cryoflow therapy is more effective than a cryogel pack in reducing pain and functional limitations.

The diminished perception of muscle soreness and improvement in the form of increasing pressure pain threshold (kg/cm^2), and reduction of both pain and function scores of PREE starting at 48 h later showed that cryoflow therapy is effective in minimizing the perceived pain and functional limitations associated with DOMS. These findings were consistent with those of similar investigations using cryotherapy as a modality to treat exercise-induced muscle damage [27–29]. Cryoflow therapy is proposed to aid recovery from muscle soreness by altering tissue temperature and blood flow. Moreover, the compressive effect of air is believed to create a displacement of fluids from the periphery to the central cavity. This hydrostatic pressure results in multiple physiological changes, including an increase in substrate transport and cardiac output as well as a reduction in peripheral resistance and extracellular fluid volume through intracellular–intravascular osmotic gradients [8,10,20].

Cryotherapy, with its ability to reduce blood circulation and membrane permeability, alters nerve conduction velocity and hence pain tolerance. It also lowers the conduction velocity of peripheral nerves [27,30]. Repeated applications of ice can decrease the pain associated with DOMS significantly at 48 h after induced muscle soreness, thus supporting the evidence that cryotherapy reduces pain and speed recovery of sore muscles after fatigue resulting from repeated maximal contractions [27]. Previous researches had shown that cryotherapy reduced perceived pain by lowering the osmotic pressure of exudates (metabolites arising from inflammation), which consequently signals the afferent projections of nerve branches. It was suggested that blood flow to muscle may be lower after cold application. This may be because of activation of the thermal nociceptors, leading to a change in sympathetic nerve activity and consequently reduced arterial flow. The physiological effect of cold is believed to be partially mediated through temperature-induced reductions in microvascular blood flow around the damage site, which in turn reduces edema and the induction of inflammatory events [27,29,30].

The findings of this study were in contrast to some studies that used cryotherapy as a modality to treat exercise-induced muscle damage [31–33]. The authors suggested that the inimitable properties associated with eccentric exercise and consequent damage seem to have a different underlying pathology than conventional injuries such as muscle strain; as a result, ice massage would not appear to have the same therapeutic effects reported for acute traumatic injury [31]. Also, previous researches evaluated the motor function after cryotherapy [32,34], the authors stated that the process of cooling skeletal muscle impairs contraction kinetics in muscle, particularly the rate of tension development and hence the excitation contraction coupling rate is diminished. It is therefore important to consider the effects of reduced muscle temperature when interpreting performance outcomes or using cold between consecutive exercise bouts as the muscle may still be at subphysiological temperature [3].

Sampling selection could limit the generalization of our findings; also, there was no treatment control group. We did active-control group (group B) for the moral issue.

Future studies investigating the effects of the same modality on biochemical factors such as serum creatine kinase are needed.

The findings of the current study might be relevant both in clinical rehabilitation and sports performance using cryoflow therapy for the treatment of DOMS, and further research can be carried out for other

musculoskeletal conditions in the future using the same modality.

Conclusion

In summary, cryoflow therapy through its both mechanical and thermal effects is effective than regular cryogel packs in minimizing the symptoms associated with DOMS.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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