

## Original Article

# EFFECT OF ICE BAG, DYNAMIC STRETCHING AND COMBINED TREATMENTS ON THE PREVENTION AND TREATMENT OF DELAY ONSET MUSCLE SORENESS

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## ABSTRACT

**Objective:** To investigate the effects of ice bag, dynamic stretching, combined ice and dynamic stretching, and control (non-treated) on the prevention and treatment of delayed onset muscle soreness (DOMS) in biceps muscle.

**Subjects:** Fifty-five participants (aged 18 to 25 years) were engaged in this study and randomly assigned into four groups (control group (non-treated) (CG), n = 13; ice bag, n = 14; dynamic stretching, n = 14; and combined treatment, n = 14).

**Method:** Before inducing DOMS, the range of motion (ROM) and maximum voluntary contraction (MVC) were measured. The dynamic stretching was performed before inducing DOMS. Subjects performed biceps eccentric exercise at 110% of the predicted one-repetition maximum (1-RM), for each subject, to induce muscle soreness. Pain, ROM and MVC were assessed at 0, 24, 48, 72, and 96 hours after induction of DOMS.

**Results:** These non-significant results for mode of treatment and time interaction showed that combined treatment, ice bag, or dynamic stretching alone is not effective at significantly reducing the symptoms of DOMS.

**Conclusion:** These results are non-significant, the pattern of the data showed that the combined treatment may be contraindicated in the prevention of DOMS and ice bag or dynamic stretching might be the best choice of treatment. Further investigation is strongly recommended.

**KEYWORDS:** Physical therapy, Exercise, Pain, Muscle Soreness, Range of Motion.

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## INTRODUCTION

Delayed onset muscle soreness (DOMS) is a phenomenon that arises from physical exertion and described as unpleasant sensation or pain after unaccustomed strenuous exercise. Sports medicine professionals use various forms of cold application and stretching on a daily basis to prevent and treat DOMS. The onset of DOMS occurs 8 to 24 hours post-exercise. It is essen-

tial that these clinicians know about the physiologic effects of cold and stretching in order to provide the most appropriate application protocols for athletes. The physiologic effects of cryotherapy are decreases in metabolism, inflammation, pain, and muscle spasm<sup>1</sup>. Cold decreases the responsiveness of the neuromuscular system, including nerve conduction velocity and specific reflex activity<sup>2</sup>.

Bags of crushed ice are commonly used in the field of sports because they are inexpensive and readily available. Moreover, ice can cool more effectively than other cold modalities, such as chemical cold packs. Ice bag application provides longer decreases in muscle temperature than ice massage<sup>3,4</sup>. The depth of cold penetration increases when compression is applied together with the cold modality. Stretching exercises are regularly included in warm-up and cooling-down exercises. Several authors have suggested that stretching has a beneficial effects on injury prevention, improve muscle flexibility and enhance physical performance<sup>5</sup>. Dynamic stretching involves moving the limb from its neutral position to its end range, where the muscles are at their greatest length, and then moving the limb back to its original position. This dynamic action is carried out in a smooth, controlled manner and is repeated for a specified time period. Dynamic stretching has been recommended as an alternative to static stretching post-warm-up, as evidence suggests that dynamic stretching positively impacts on immediate physical performance<sup>5,6</sup>. The purpose of this study was to compare the effects of ice bags, dynamic stretching, and combined ice bag and dynamic stretching on the prevention and treatment of DOMS.

## METHODS

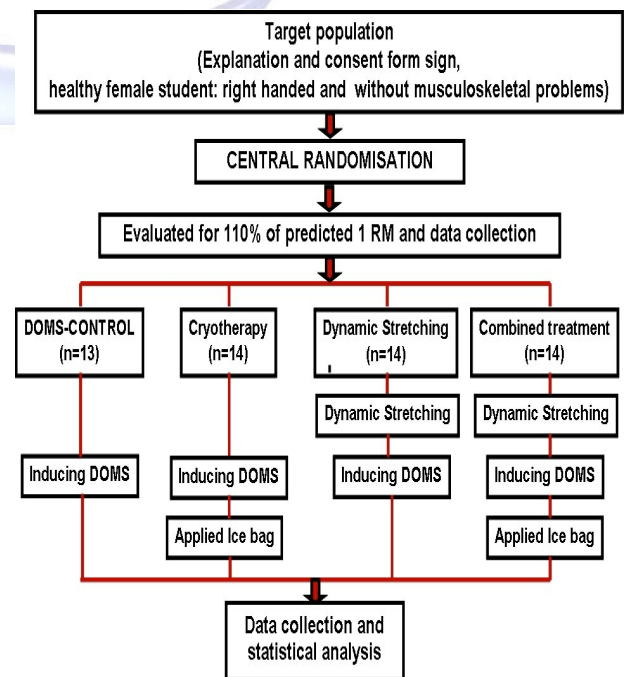
Fifty-five participants aged between 18 to 25 years were engaged in this study and were randomly assigned into four groups (control group (non-treated) (CG), n = 13; ice bag, n = 14; dynamic stretching, n = 14; and combined treatment, n = 14). The subjects were healthy female students (right handed), without musculoskeletal problems, from Srinakharinwirot University. General data of the subjects are presented in Table 1. All subjects were informed about the purpose of the study, testing procedure, and instructions and signed the consent form. We instructed all subjects not to stretch, massage, or engage in any other treatment or therapy and to abstain from taking any medication during the study. Ethical approval for the protocol was obtained from Srinakharinwirot University Ethics Committee prior to the study.

**Table 1:** Means and standard deviations of weight, height, body mass index (BMI), age, biceps skin fold, triceps skin fold, and arm circumference (p = 0.200).

	Ice bag (N=14)	Dynamic Stretching (N=14)	Combined Ice bag and dynamic stretching (N=14)	Control (Non- treated) (N=13)	P-value
Body mass index (BMI)	20.16±1.83	20.59±2.25	20.62±2.90	21.14±1.80	P=0.20
Weight (Kg)	51.90±4.5	52.14±6.4	52.18±8.1	54.12±3.03	P=0.20
Height (cm)	160.6±5.8	158.93±3.7	159±4.4	160.23±5.6	P=0.20

We randomly assigned subjects to each of the treatment groups and control. The dependent variables measured were pain (detected by visual analogue scale, VAS), range of motion (ROM), and strength (maximum voluntary contraction, MVC). Our 5x4 factorial design allowed the statistical analysis of time (5 periods), the main effect of intervention (4 groups), and the interaction between times and treatments. (Figure 1)

**Fig. 1:** Study procedure. Dependent variables were measured for subjects and they were randomly divided into four groups (control non-treated, ice bag, dynamic stretching, and combined treatments).



### Pre-DOMS-induction measurements

The predicted one-repetition maximum (1-RM) was presented by ACSM in 2000<sup>7,8</sup>. We evaluated the predicted 1-RM for left biceps muscles for

each subject using dumbbells to determine the appropriate weight. The predicted 1-RM value was used to determine the amount of weight to lift to induce DOMS. We measured the MVC and active ROM by standard goniometer. For ROM measurement, the pivot of the equipment was over the lateral epicondyle. The stationary arm was aligned with the lateral midline of the humerus, and the movable arm was aligned with the radius. The neutral position was set at 180° (arm straight). The total difference in ROM was calculated from the degrees of full flexion and extension.

A handheld dynamometer was used to detect the MVC of biceps muscle. Each subject sat with the forearm on the arm supported in a supine position (elbow flexion at 90°). The dynamometer was placed perpendicular to the wrist. The MVC was detected twice and the best amount was used. Pain or soreness was determined by the standard VAS method (by 10 cm line).

### **Induction of DOMS**

The induction was adapted from Paddon-Jones and Quigley (1997)<sup>9</sup> (1). The non-dominant arm was selected for this study. The biceps muscle exercise (eccentric exercise) was performed by using 110% of predicted 1-RM weight. The subject held the 110% of predicted 1-RM weight in the full flexion position and let the weight drop slowly until full extension within 3 seconds (using a metronome). We helped the subject to hold the weight while moving back to full flexion (passive full support), and then the eccentric exercise was repeated eight times per set. A total of eight sets were used in this induction protocol (with 30 seconds' rest between the sets).

### **Dynamic stretching**

Dynamic stretching was achieved before the induction of DOMS in the dynamic stretching group and combined treatment group. This method was modified from Brandy et al. (1998)<sup>8</sup>. Each subject was instructed to actively swing the forearm to be stretched backward while the shoulder was moved to extension until a stretch was felt in the biceps muscle. The forearm was then allowed to swing back into shoulder flexion. This was repeated six times per set. A total of three sets were performed in this study (with

one minute's rest between the sets).

### **Ice bag**

The ice bag comprised crushed ice in a plastic bag and was applied with polyethylene wrap on top of the biceps muscle. It was applied in the ice bag group and combined treatments group for 20 minutes immediately after DOMS induction.

### **Post-DOMS-induction measurements**

After inducing DOMS, measurements of strength, ROM, and perceived pain were acquired following the same protocol as for pre-DOMS-induction. Post-DOMS-induction measurements for all variables were performed at 0 (immediately after inducing DOMS), 24, 48, 72 and 96 hours after inducing DOMS. Moreover, the strength was measured at two time points (before inducing DOMS and 96 hours after inducing DOMS).

### **Data analysis**

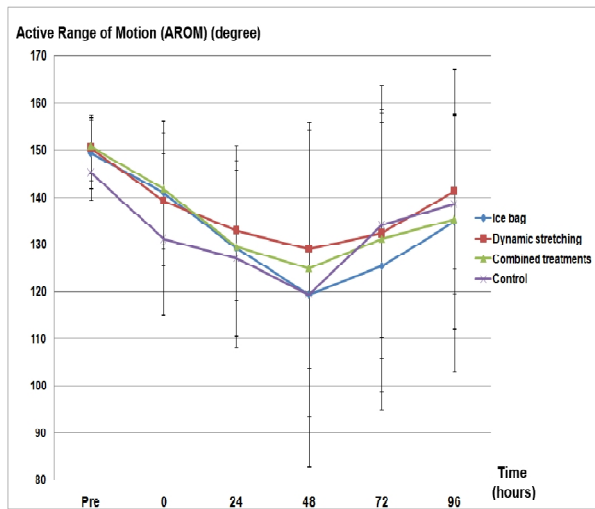
Two-way mix model ANOVA was used to study and compare different among treatment groups. Statistical significance was considered at the  $p < 0.05$  level. Where applicable, Tukey post hoc procedures were utilized to identify significant differences for these data.

## **RESULTS**

The subjects in this study were female undergraduate students aged 18–25 years ( $22.07 \pm 1.13$ ) ( $p = 0.2$ ). The purpose of this study was to investigate the effects of ice bag, dynamic stretching, and combined treatments (ice bag and dynamic stretching) for prevention and treatment of DOMS. We found that the treatment or time interactions showed no significant differences ( $p > 0.05$ ). Interestingly enough, the ice bag and combined treatment groups showed a tendency towards decreased ROM when compared to the control and dynamic stretching groups, respectively (Figure 2). The greatest decrease in ROM was presented at 48 hours after inducing DOMS in every group (Table 2). The pain perception results showed that the dynamic stretching group had the lowest perceived pain and the ice bag treatment group had the highest perceived pain in the biceps muscle (at 0 hours after inducing DOMS) (Figure 3A). Perceived pain was highest at 24

and 48 hours after induced DOMS in every group (Table 3). Fascinatingly, the dynamic stretching group presented the smallest percentage difference (102.80%) at 96 hours after inducing DOMS compared to 0 hours after inducing DOMS (Figure 3B). This percentage difference from the measurement at 0 hours after inducing DOMS was also used for comparing the effects of treatment. We found that the control group showed the best recovery with regard to pain perception.

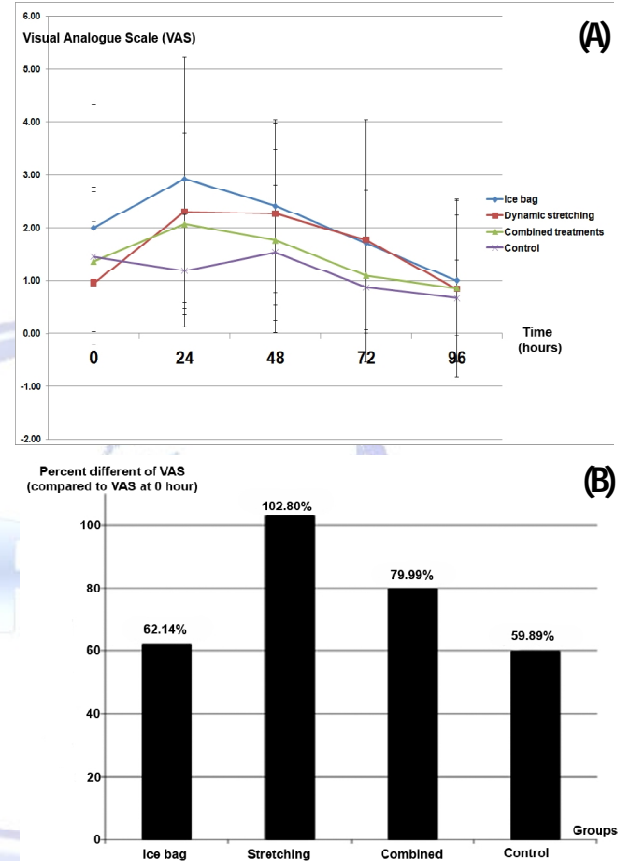
**Fig. 2:** Change in active range of motion (ROM) with respect to treatment groups (control non-treated, ice bag, dynamic stretching, and combined treatments) at different time points (0, 24, 48, 72, and 96 hours) after inducing DOMS.



**Table 2:** Means and standard deviations of active range of motion (ROM) of elbow movement at 6 different time points (pre-inducing DOMS, pre; immediately after induced DOMS, 0; 24 hours after induced DOMS, 24; 48 hours after induced DOMS, 48; 72 hours after induced DOMS, 72 and 96 hours after induced DOMS, 96). The results showed non-significant different among all groups ( $p > 0.05$ ).

Times (hours)		Pre	0	24	48	72	96
Ice bag	mean	149.43	141.00	129.29	119.36	125.36	134.79
	SD	7.58	15.43	18.52	36.52	30.46	22.56
Dynamic stretching	mean	150.50	139.29	133.00	129.07	132.36	141.29
	SD	7.00	10.11	14.84	25.25	26.32	16.46
Combined treatments	mean	150.79	141.86	129.57	124.93	131.29	135.21
	SD	5.75	11.63	21.37	31.15	32.42	32.01
Control	mean	145.23	131.23	127.08	119.46	134.08	138.62
	SD	5.75	16.08	18.83	36.45	23.74	18.96

**Fig. 3:** Change in visual analogue scale (VAS) with respect to treatment groups (control non-treated, ice bag, dynamic stretching, and combined treatments) at different time points (0, 24, 48, 72, and 96 hours) after inducing DOMS (A). Percentage difference in VAS between pre-DOMS-induction and post-DOMS-induction at 96 hours; the dynamic stretching group showed the smallest percentage difference in pain perception when compared to the other groups (B).



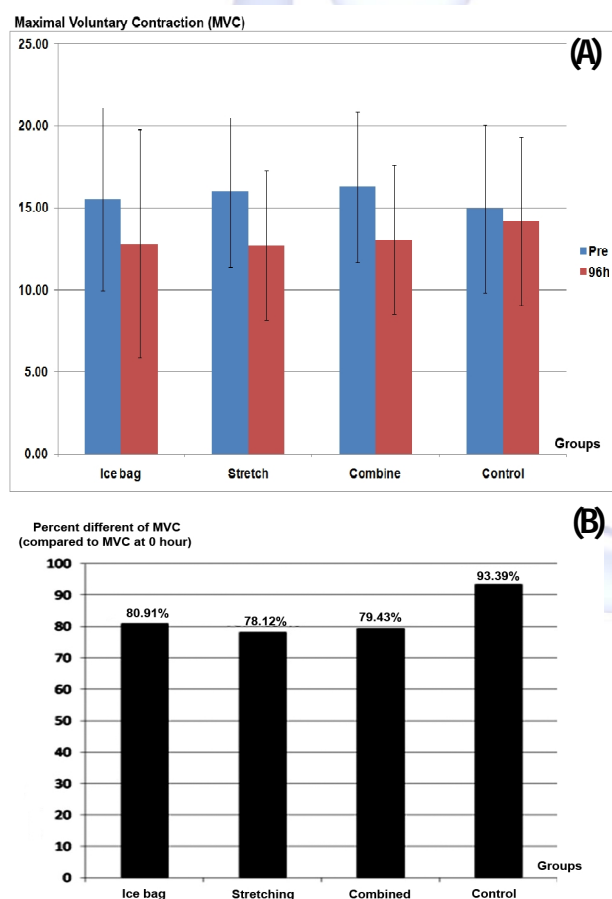
**Table 3:** Means and standard deviations of visual analogue scale (VAS) of biceps muscle at 5 different time points (immediately after induced DOMS, 0; 24 hours after induced DOMS, 24; 48 hours after induced DOMS, 48; 72 hours after induced DOMS, 72 and 96 hours after induced DOMS, 96). The results showed non-significant different among all groups ( $p > 0.05$ ).

Times (hours)		0	24	48	72	96
Ice bag	mean	2.00	2.92	2.41	1.71	1.00
	SD	2.32	2.32	1.64	1.64	1.51
Dynamic stretching	mean	0.96	2.30	2.26	1.77	0.85
	SD	1.15	1.81	1.72	2.27	1.39
Combined treatments	mean	1.36	2.07	1.76	1.09	0.86
	SD	1.33	1.71	1.73	1.62	1.69
Control	mean	1.46	1.19	1.53	0.88	0.68
	SD	1.32	1.05	1.28	0.87	0.72

The strength of the biceps muscle was detected by maximum voluntary contraction (MVC) and compared between pre-induction of DOMS and 96 hours after inducing DOMS (Table 4). We

found that the MVC was not significantly different between each group (Figure 4A). We also used the percentage difference in strength for comparison between pre-induction of DOMS and 96 hours after inducing DOMS in each group to show the effects (Figure 4B). The control group showed the best recovery of strength when compared to the other groups and the dynamic stretching group showed the worst.

**Fig. 4:** Shows the maximum voluntary contraction (MVC) between pre-DOMS-induction and post-DOMS-induction at 96 hours (A). The percentage difference in MVC between pre-DOMS-induction and post-DOMS-induction at 96 hours. There were no significant differences among treatment groups (combined treatments, dynamic stretching, ice bag, and control-DOMS) (B).



**Table 4:** Means and standard deviations of maximal voluntary contraction (MVC) of biceps muscle at 2 time points (pre-inducing DOMS, pre and 96 hours after induced DOMS, 96). The results showed non-significant different among all groups ( $p > 0.05$ ).

Times (hours)		Pre	96
Ice bag	mean	15.52	12.79
	SD	4.57	4.57
Dynamic stretching	mean	15.94	12.71
	SD	4.56	4.56
Combined treatments	mean	16.27	13.02
	SD	5.11	5.11
Control	mean	14.94	14.18
	SD	5.52	6.94

## DISCUSSION

The mechanisms of DOMS after exercise are controversial, making information about prevention and treatment scarce. Then the study of mechanisms, treatments, and preventions was presented in literature resources<sup>10-12</sup>. We attempted to present the effects of prevention and treatment of DOMS through the use of ice bag, dynamic stretching, and combined treatments. We found that there were no significant differences in mode of treatment and prevention and time parameters. These findings are similar to those of previous studies<sup>9, 13, 14</sup>. Interestingly, the peak in pain perception was found to occur between 24 and 48 hours after inducing DOMS in all groups<sup>4-7</sup>. The maximum pain perception in the same period showed the consequences and the effectiveness of the DOMS-inducing programme.

Putting the previous information together with our knowledge, it can be stated that cryotherapy must be useful for soft tissue injury. It has been reported that the mechanisms responsible for muscle adaptation and repair and subsequent relief from DOMS symptoms may centre on physiological responses that are adversely affected by cold application; however, there is still controversy concerning the previous research results<sup>12, 19</sup>. In our study, we applied the ice bag immediately after inducing DOMS (in both ice bag and combined treatment groups). Despite these changes, no significant differences were found compared to other techniques and time interactions. Since there were no significant differences between the modes of treatment, we cannot conclude which technique prevents and treats the DOMS. However, a possible mechanism is the accumulation of waste products in soft tissue after induction of DOMS. The effect of immediate vasoconstriction due to cold after inducing DOMS might interrupt the draining of waste products in the soft tissue<sup>20, 21</sup>. Noxious substances are also released after inducing DOMS, which also disrupts the vasoconstriction effect. The noxious receptor is stimulated by these substances, which can cause an increase in pain perception<sup>22</sup>.

The ROM in each group also showed no significant differences in relation to time. Fascinatingly, ice bag and combined treatments groups showed faster recovery (compared to the ROM at 0 hours after inducing DOMS) than others at 48 hours after DOMS-induction (data not shown). It might be possible that the cryotherapy affects soft tissue healing during the acute phase. Our results correspond with those of McLean (1989), who found that immediate treatment by cryotherapy promotes soft tissue healing better than late treatment<sup>23</sup>.

Maximum voluntary contraction (MVC) was detected in each group pre-DOMS-induction and 96 hours after inducing DOMS. We found that the ice bag group showed higher MVC at 96 hours, which is equivalent to the results of pain perception. It might be possible that the effect of facilitating the healing process by cryotherapy can assist better recovery of muscle function after injury. Interestingly, the combined treatments group showed similar effects to the ice bag group. Dynamic stretching has been recommended as an alternative to static stretching post-warm-up because of the impact on physical performance<sup>5</sup>. Our observations from the subjects of the dynamic stretching and combined treatments groups informed us about fatigue after finishing the dynamic stretching. An effect of fatigue on force absorption during muscle contraction has been reported. The decrease in force absorption might increase the risk of injury after exercise and slow down the process of healing of soft tissue after injury<sup>24</sup>.

Although these results are not significant, some limitations are evident. The VAS in this study was the data from resting position or non-activity. These may not be the precise data for VAS in the DOMS condition<sup>22</sup>. The consistency of pressure from wrapping in an ice bag in both ice bag and combined treatments groups might have affected the results. Moreover, our study was investigated only one time treatment for each group after induced DOMS, which different to the clinical treatments. The repetitive treatment with cold water has been proved that decreased pain after DOMS<sup>21, 25</sup>. Therefore, the effects of number of treatment are recommended for further study.

## CONCLUSION

This study provides additional support for the proposition that repeated eccentric exercise produces DOMS. The increase in pain perception and decrease in ROM corresponded similarly to the aetiology of DOMS. No significant differences were found between the therapeutic use of ice bag, dynamic stretching, or combined treatments or in relation to time parameters. The combined treatment may be contraindicated for the prevention of DOMS and ice bag or dynamic stretching might be the best choice for treatment and prevention.

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**Conflicts of interest:** None

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