Comparison of Combined Effect of Cold Water and Ultrasound, with Cold Water alone, in Treatment of Delayed Onset Muscle Soreness

Ms. Mandeep Kang [1], Dr. G.S. Kang [2]

ABSTRACT

Delayed onset of muscle soreness (DOMS) is a common phenomenon experienced by anyone who has undergone unaccustomed exercise. The purpose of this study was to formulate a comparative analysis between the effect of cryotherapy in the form of cold water immersion in combination with thermal ultrasound, and cold water immersion alone, on the treatment of DOMS.

Twentyone healthy normal individuals (10 males and 11 females), aged between 20-25 years, were randomly assigned to these groups (cold water immersion group, cold water immersion + thermal ultrasound group and control group). DOMS was induced with four sets of ten maximal eccentric contractions of the left arm biceps.

Main outcome was measured. Subjects in their respective groups were treated 24 hrs. and 48 hrs. post exercise. Pain perception was measured by Visual Analogues Scale (VAS scores), Relax Arm Angle (RAA) and upper arm circumference pre and post treatment.

One-way ANOVA showed significant differences, in all the groups, regarding VAS scores and RAA measurements. The subjects 't'-test showed highly significant treatment differences for VAS scores and RAA measurements in cold water immersion and thermal ultrasound group ('t'-value=9.76 and 15.42, respectively; $p<0.0001$); and moderately significant treatment differences for cold water immersion group ('t'-value = 4.10 and 7.93, respectively; $p<0.001$); but no significant treatment differences for upper arm circumference measurements were revealed in either of the group, when compared to the control group.

Results indicate that though both the modalities, when given to the subject, in combination, may give far better results regarding VAS scores and RAA measurements than when cold water immersion is given alone. It is suggested that, while treating DOMS, a combination of cold water immersion + thermal ultrasound will give more relief to the patient.

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1. Lect. Physiotherapy, Guru Ram Dass Medical College, Amritsar.
2. Prof. & Head, Deptt. of Physical Education, Punjabi University, Patiala.

INTRODUCTION

During normal activities of daily life our musculoskeletal system is continually subjected to mechanical stresses. In normal healthy individuals, these stresses do not cause injury. However, during sports activities, these stresses change dramatically and can cause injuries. In the past decade, the interest of health professionals in the treatment of such injures has increased. This has resulted in a large amount of research in patho-physiological, diagnostic and therapeutic aspects of these injuries. Delayed onset muscle soreness (DOMS), following physical training, is one such common phenomenon experienced by anyone who has undergone unaccustomed exercise. Exercise-induced muscle damage which commonly occurs after strenuous eccentric muscle action consists of a dull aching pain, stiffness, tenderness and prolonged loss of muscle strength. The symptoms tend to develop within the first 24 hours post-exercise, peak between 24 and 72 hours, and then subside after 5-7 days (Ebbeling & Clarkson, 1989; Armstrong, 1990; Cleak & Eston,1992; Nosaka & Clarkson, 1995).

Additional symptoms of exercise-induced muscle damage include swelling and decrease in the range of motion. Studies on the arm have observed an increase in volume (Talag, 1980); increase in circumference measurements (Fridan et al, 1998); and, a decrease in active and passive ROM in both flexion and extension of elbow (Clarkson & Newham, 1984). In addition, when the arm is hanging in a relaxed position, the elbow angle is reduced (Cleak & Eston,1992b).

No consensus exists for the choice of treatment for this type of muscle damage. Several types of cryotherapy and electrotherapeutic modalities, including ultrasound, have been tried to ameliorate the soreness in exercise induced muscle damage. The response of soft tissues to various forms of cryotherapy and temperatures application, in both humans and animals, has been reviewed extensively (Meeusen & Lievens, 1986). A major cause of inflammation, after acute muscle injury, is an increase in capillary permeability, which in conjunction with an increase in extra cellular protein concentration and vasodilation, results in edema (Schoberth, 1980). This response varies directly with tissue temperature. A decrease in tissue temperature results in a reduction in nerve conduction velocity and activity of muscle spindle. This decreases the stretch reflex response and spasticity of muscle, which reduces the pain spasm cycle and contributes to relief of pain. Thus, when cryotherapy is applied at an appropriate frequency and duration to injured muscle, it reduces the inflammatory response and alleviates spasm and pain, after muscle injury.

Hasson et al (1990) conducted a study of the individuals with delayed onset muscle soreness and found that pulsed ultrasound therapy, reduced soreness significantly. One possible explanation for these results comes from the physiological effect of ultrasound, which proves for an increase in collagen fibers; extensibility alterations in blood flow; change in muscle contractile activity; changes in membrane

permeability; and an increase in enzymatic activity. Heat causes vasodilatation and subsequent increase in blood profusion, thereby ensuring adequate delivery of metabolites, needed for tissue repair and for adequate removal of waste products. The treatment with heat may increase the rate of biochemical reactions and also accelerate the diffusion rate across the biological membranes. Thermal ultrasound was used, in the study, with thermal effect of intensity of greater than 0.8 watts/cm2.

Objective of study

1. To examine the effectiveness of cold water immersion in the treatment of delayed onset muscle soreness.
2. To evaluate the combined effectiveness of cold water immersion and ultrasound therapy in the treatment of delayed onset muscle soreness.
3. To compare the combined effectiveness of cold water immersion along with thermal ultrasound therapy and cold water immersion alone, in the treatment of delayed onset muscle soreness.

The purpose of this study was to examine the efficiency of cold water immersion in combination with ultrasound, and of cold water immersion alone, in the treatment of delayed onset muscle soreness.

METHODOLOGY

Twentyone healthy, unrelated, normal individuals, aged between 20-25 years, provided informal consent to participate in the study. The study was conducted for the period of 3 weeks. Prior to and during testing, participants were asked to refrain from any form of resistance training, plyometrics exercise that may potentially cause muscle trauma, damage or soreness. On day one, the subject's elbow flextion at 1-RM were determined. The 1-RM represented the amount of weight which elbow flexors could lift by one concentric contraction. The subject was required to lift the weight in his hand from a fully extended to a fully flexed position. The weight lifted was increased gradually until the subject could no longer perform the full elbow flexion. Using the 1-RM weight, the subject performed repeated eccentric contraction, while holding the weight. After full extension and completion of eccentric contraction the arm was returned to the flexed position. Each subject was required to perform 4 sets of 10 repetitions of the described exercise with a two- minute rest between each of the sets. This protocol used by Coccone et al (1991) was applied to induce DOMS in the elbow flexors.

Treatment groups

Groups	*Treatment*
I	Cold Water immersion
II	Cold Water immersion + Thermal ultrasound
III	Control (no treatment)

Measurement of Pain intensity

It was measured by Visual Analogue Scale (VAS).

Measurement of Relaxed Arm Angle

It was measured by the Double Arm

Goniometer used to measure the relaxed arm angle, before and after treatment, on day 1 to 3. However, swelling was measured by flexible tape to determine the upper arm circumference at the mid belly of the biceps.

Cold Water Immersion Therapy

It was given by submerging their exposed exercised arm by ensuring that the origins and insertions of the biceps were fully submerged into a plastic bucket of water. This treatment was applied continuously for 3 days.

Thermal Ultrasound Treatment

It was given to the part of the body to be treated, the patient was made to lie down in a comfortable position on the treatment couch. Skin preparation was done by lowering the skin resistance by cleaning it with water.

RESULTS & DISCUSSION

Analysis of pain

As shown in Table 1, significant decrease in the VAS score of Group-I was observed when pre-treatment and 3rd day post-treatment values were compared (mean=5.78 and 3.71), respectively ('t'- value = 4.10,< 0.001). It shows significant decrease in the VAS scores. In Group-II (mean =5.85, 2.57), respectively ('t'- value = 9.76, < 0.001). It is also showed significant reduction in VAS scores of control group on 3rd day of treatment. However, positive effects were clear from 2nd day onwards.

Table-1 : Comparison of pain scores before treatment and after 2nd day and 3rd day of treatment, within Group-I (Cold water immersion), Group-II (Cold water immersion + Thermal Ultrasound), and Group-III (Control) in the treatment of DOMS.

	GROUP-I				GROUP-II				GROUP-III			
Period of treatment	Cold Water immersion (n = 7)				Cold Water immersion + Thermal ultrasound (n = 7)				Control (n = 7)			
	Mean	S.D.	S.E.	't' - value	Mean	S.D.	S.E.	't' - value	Mean	S.D.	S.E.	't' - value
Pretreatment	5.78	0.795	0.30	2.56	5.85	0.692	0.26	5.61*	5.64	0.900	0.34	1.53 NS
2nd day	4.92	0.727	0.27		4.28	0.642	0.24		4.85	0.920	0.34	
Pretreatment	5.78	0.795	0.30	4.10	5.85	0.692	0.26	9.76*	5.64	0.900	0.34	1.53
3rd day	3.71	0.994	0.37		2.57	0.774	0.29		3.92	0.829	0.31	

* Significant at 0.001 level

Table 2 gives the clear information regarding RAA improvement. It reveals that maximum relief was observed in Group-II, and that also after 3rd day of treatment ('t' - value = 15.42, < 0.001).

Table-2 : Comparison of relaxed arm angle, before treatment, after 2nd day and after 3rd day of treatment within Group-I (Cold water immersion), Group-II (Cold water immersion + Thermal Ultrasound) and Group-III (Control) in the treatment of DOMS.

	GROUP-I				GROUP-II				GROUP-III			
Period of treatment	Cold Water immersion (n = 7)				Cold Water immersion + Thermal ultrasound (n = 7)				Control (n = 7)			
	Mean	S.D.	S.E.	't' - value	Mean	S.D.	S.E.	't' - value	Mean	S.D.	S.E.	't' - value
Pretreatment	129.10	0.96	0.36	3.64*	129.5	0.896	0.33	6.23*	130.4	0.964	0.36	1.76 NS*
2nd day	131.40	0.93	0.35		132.5	0.865	0.22		131.4	0.950	0.35	
Pretreatment	129.10	0.96	0.36	7.93*	129.5	0.896	0.33	15.42*	130.4	0.964	0.36	2.10*
3rd day	133.20	0.84	0.31		136.5	0.766	0.28		132.7	0.930	0.35	

* Significant at 0.001 level

Also significant improvement was shown in Group-I on day 3rd of treatment (mean=129.10 and 133.20, respectively ('t'-value = 7.93; significant at 0.00 level).

Similar trend like that of VAS score was observed in the Control Group regarding RAA measurements. Unlike other two groups, this group showed very little improvement in RAA, that is a total gain of only 2 of RAA, even after 3rd day of treatment.

Analysis of Circumference

The results regarding upper arm circumference showed a different trend as compared to other two variables. As shown in Table 3, no treatment mode was found significantly effective regarding decreased upper arm circumference associated with DOMS. When comparison between pre-treatment values and 3rd day values of group-II was made, no significant results emerged (mean=24.90 and 24.10, respectively), and ('t'- value = 1.33 NS).

Table-3 : Comparison of upper arm circumference before treatment, after 2nd day and after 3rd day of treatment with in Group-I (Cold water immersion), Group-II (Cold water immersion + Thermal Ultrasound) and Group-III (Control) in the treatment of DOMS.

	GROUP-I				GROUP-II				GROUP-III			
Period of treatment	Cold Water immersion (n = 7)				Cold Water immersion + Thermal ultrasound (n = 7)				Control (n = 7)			
	Mean	S.D.	S.E.	't' - value	Mean	S.D.	S.E.	't' - value	Mean	S.D.	S.E.	't' - value
Pretreatment	26.5	1.20	0.45	0.083 NS*	24.9	1.03	0.38	0.15 NS*	26.54	1.55	0.58	0.013 NS*
2nd day	26.4	1.15	0.43		24.8	1.00	0.37		26.52	1.51	0.57	
Pretreatment	26.5	1.20	0.45	0.013 NS*	24.9	1.03	0.38	0.15 NS*	26.54	1.55	0.58	0.294 NS*
3rd day	26.4	1.00	0.27		24.1	9.32	0.35		26.50	1.40	0.52	

* P < 0.001; N.S. = Non Significant

Table-4 : One-way analysis of variance (ANOVA) showing variation among all the groups regarding visual analogues scale (VAS) scores after 3rd day of treatment.

Analysis of Variance	df	TSS	Mean SS	'F' Value
Variations between the subjects	6	5.98	1.00	1.006 NS
Variations between the groups	2	7.45	3.73	3.7635*

* P < 0.05

Table 4 shows the one-way analysis of variance (ANOVA) regarding VAS scores among all the subjects and groups. It shows that there was no significant difference in the results of treatment among the subjects; but, the difference did exist among the groups after 3rd day of treatment (F value = 3.7635, $p<0.05$).

Table-5 : One-way analysis of variance (ANOVA) showing variation among all the groups regarding relax arm angle (RAA) measurements after 3rd day of treatment.

Analysis of Variance	df	TSS	Mean SS	'F' Value
Variations between the subjects	6	24.94	4.16	0.8128 NS
Variations between the groups	2	50.66	25.33	4.9535*
Residual Error	12	61.36	5.11	
Total	20	136.95		

* P < 0.05; N.S. = Non Significant

Table 5 shows that there were non significant differences among the subjects; but, statistically significant difference in treatment effects was revealed among three groups after 3rd day of treatment (F value= 4.9535 at 0.05 level of confidence).

Table-6 : One-way analysis of variance (ANOVA) showing variation among all the subjects and Groups regarding upper arm circumference measurements after 3rd day treatment.

Analysis of Variance	df	TSS	Mean SS	'F' Value
Variations between the subjects	6	19.34	3.22	0.3775 NS
Variations between the groups	2	13.85	6.92	0.8109 NS
Residual Error	12	102.47	8.54	
Total	20	135.66		

* N.S. = Non Significant

Table 6 shows that there was no significant treatment difference either among subjects or groups, regarding upper arm circumference, after 3rd day of treatment (F value= 0.8109 NS).

Table-7: Comparison of pain scores (VAS) among cold water immersion, (Cold water immersion + Thermal Ultrasound) and control groups in treatment of DOMS on pretreatment and 3rd day.

Treatment Group	Pretreatment			3rd Day			
	Mean	SD	SE	Mean	SD	SE	't'-value
Cold Water Immersion (Group-I)	5.70	0.79	0.30*	3.71	0.99	0.37	3.84*
Cold Water immersion + Thermal Ultrasound (Group-II)	5.80	0.69	0.26	2.57	0.71	0.29	3.16*
Control (Group-III)	5.60	8.90	0.34	3.92	0.82	0.31	

* P < 0.01, N.S. = Non Significant

As shown in Table 7, the significant difference was observed in VAS scores, on the 3rd day of treatment, between Group-II and Group-III, (mean= 2.57 and 3.92 and 't'-value = 3.16). Also, the most significant differences was observed between treatment results of Group-I and Group-II regarding VAS (mean= 3.71 and 2.70, respectively and 't'-value = 3.84 significant at 0.01 level).

Table-8: Comparison of relaxed arm angle (RAA) among cold water immersion, (Cold water immersion + Thermal Ultrasound) and control groups in treatment of DOMS on pretreatment and 3rd day.

Treatment Group	Pretreatment			3rd Day			
	Mean	SD	SE	Mean	SD	SE	't'-value
Cold Water Immersion (Group-I)	129.10	0.960	0.36	133.50	0.843	0.31	6.45*
Cold Water immersion + Thermal Ultrasound (Group-II)	129.50	0.890	0.33	136.50	0.766	0.28	7.73*
Control (Group-III)	130.40	0.964	0.36	132.70	0.930	0.35	

* P < 0.001

A highly significant difference was observed in RAA, on the 3rd day of treatment, between Group-I (cold water immersion) and Group-II (cold water immersion + thermal ultrasound), where (mean =133.50 and 136.50, respectively; 't'- value = 6.45 at 0.001 level); and between Group-II and Group-III (Mean=136.50 and 132.70, respectively; 't' value = 7.73, < 0.001) again showed the same trend, insignificant difference regarding VAS and RAA between Group-I and Group-III.

It's very clear that maximum per centage of relief from pain perception and stiffness happened to the subjects of Group-II (cold water immersion + thermal ultrasound therapy). Group-I (cold water immersion) followed Group-II (Cold water immersion + Thermal ultrasound) in terms pain relief and relax arm angle.

Results of the present study revealed that significant improvement was recorded in cold water immersion group and cold water immersion + thermal ultrasound group, as compared to control group, in terms of pain relief and relaxed arm angel, at the end of three days of treatment. But, no significant improvement in terms of upper arm circumference reduction was recorded in either of the group. The cold water immersion + thermal ultrasound group showed more significant improvement followed by cold water immersion group and control group.

The results of the present study are inconsistent with the finding of Caraig et al (1990) and Plaskett et al (1999) regarding the effect of ultrasound. They stated that use of ultrasound over three consecutive days made insignificant difference in the management of DOMS. However, the results are in accordance with the findings of Hasson et al (1990). They showed that ultrasound effectively reduces the soreness 48 hours post eccentric activity.

One possible explanation for these results, on the basis of physiological effects of ultrasound, could be that the sonic waves are associated with thermal and non-thermal effects. Thermal Ultra Sound tends to have physiologic effects like deep heating, relieving pain through sedative effects of vasodilatation. Another advantage of using ultrasound, to achieve heating, is due to the effective penetration of this energy to deeply placed structures (Dyson, 1987).

Results of the present study, regarding the effect of cold water immersion (cryotherapy), are inconsistent with the finding of Paden Jones and Quigley, (1997) and Howatson and Someren, (2001). They stated that use of cryotherapy made a significant difference in the management of DOMS. However, the results are in accordance with the findings of Roger, Eston and Daniel, Peters (1988) and Prentice (1982) who showed that cryotherapy was significantly effective in inducing muscle relaxation, increasing relaxed arm angle and decreasing tenderness, if applied for three days after eccentric exercises.

Results of the present study indicated that no significant improvement was noticed in cold water immersion + thermal ultrasound group and

cold water immersion group in terms of upper arm circumference as compared to the control group, at the end of three days of treatment. So, the results of the present study regarding the non-significant reduction in upper arm circumference after treatment is not in accordance with the results of Roger, Eston and Daniel, peters (1988) and Howaston and Someran, (2001). They, after their respective studies, concluded that cryotherapy is an effective treatment mode for decreasing the circumference of the eccentrically exercised limb. The results of this study, regarding upper arm circumference measurements, are in line with conclusion of the study conducted by Yackzen et al (1984). They stated that cryotherpay does not have any significant effect on eccentrically exercised limb circumference.

CONCLUSIONS

- Some significant improvement is noted in subjects of Group I (cold water immersion) as compared to Group-III in terms of improvement of pain relief and relaxed arm angle.
- Highly significant improvement is noted in subject of Group-II (cold water immersion + thermal ultrasound) as compared to Group-III (control) in terms of improvement of pain relief and relaxed arm angle.
- No significant improvement is noted in subjects of Group-I (cold water immersion) as compared to Group-III (control group), in terms of reduction of upper arm circumference.
- No significant improvement is noted in subjects of Group-II (cold water immersion + thermal ultrasound) as compared to Group-III (control), in terms of reduction of upper arm circumference.
- Group-II (cold water immersion + thermal ultrasound) has shown the highest improvement in relief of pain and RAA followed by Group-I (cold water immersion) and Group-III (control group).

CLINICAL IMPLICATIONS

Clinical implication of the results suggest that using cold water immersion and thermal ultrasound, in combination, will give far better results as compared to cold water immersion alone, in relieving pain and stiffness associated with DOMS.

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