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Research article

A COMPARITIVE STUDY ON CRYO, PULSED ULTRASOUND AND ITS COMBINATION THERAPIES ON DELAYED ONSET OF MUSCLE SORENESS

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ABSTRACT

Objectives: Individuals engage in strenuous physical activity to which they are unaccustomed usually land up in a phenomenon called Delayed Onset of Muscle Soreness (DOMS) and results in pain, muscle stiffness and swelling. The current study was aimed to see the effect of cryo, ultrasound and its combination therapies on the reduction of symptoms of DOMS. **Materials and Methods:** A total of 30 subjects with the mean age of 22.1 ± 5.9 years participated in the study. Subjects were randomly allocated to three groups A, B and C (n=10) and induced DOMS by a standard exercise protocol. Each group received different treatment application i.e. ultrasound (US), cryotherapy (CT) and combination (C) of both. Study outcomes were measured by Perceived Muscle Soreness (PMS), Relaxed-Elbow flexion angle (rEFA), Plasma Creatine Kinase (CK) level at 0 hours (pre-exercise), 24hrs, 48hrs, 72hrs and at 92hrs. **Results:** All three groups showed improvement with respect to their interventions, whereas the C group, after 96 hours of post-exercise the rEFA return to its near normal range as compared to the other two groups. Although there was a rise in the plasma CK level in all three groups, however the C group was effective in minimizing the rising level of CK and also in the reduction of muscle soreness at successive time intervals and reaches to baseline after 96 hours of post-exercise. **Conclusion:** The combined application of cryotherapy and pulsed ultrasound immediately after exercise induced muscle damage is a better choice of treatment, It is also observed that cryotherapy was more effective than pulsed ultrasound alone treatment in reduction of symptoms.

Key words: Muscle soreness, Cryotherapy, Ultrasound, Range of motion, Creatine Kinase

INTRODUCTION

Delayed onset muscle soreness (DOMS) refers to the skeletal muscle pain that follows novel eccentric exercise.[1,2] The intensity of soreness increases during the first 24 hrs, peaks at 24–48 hrs, and subsides within five to seven days of postexercise.[1] The sore muscles are described as feeling stiff, tender, and aching especially after palpitation or movement but these common

symptoms rarely require medical attention.[1,3] DOMS is typically experienced by all individuals regardless of fitness level, and is a normal physiological response to increased exertion, and the introduction of unfamiliar physical activities. It can occur any number of times throughout one's life[4]. Researchers hypothesis that DOMS is related to muscle structural damage that is followed by ion imbalance, inflammation, and pain[1,2,3]. Muscle damage includes disrupted sarcolemma, T-tubules, myofibrils, cytoskeletal protein, and sarcoplasmic reticulum (SR) [3,5,6]. Immediate soreness may be due to bio-mechanical end products of metabolism affecting nerve endings or temporary hypoxia due to muscle ischemia. Severity of the soreness depends upon the complexity of the exercise[7]. Due to the sensation of pain and discomfort, DOMS can impair physical fitness and performance, so prevention and treatment of DOMS is of great concern to coaches, trainers, and therapists[8].

Some strategies proposed to alleviate DOMS include pre and post-exercise stretching, light exercise, ultrasound, topical analgesics, and it is also common for the clinician to recommend NSAIDs to decrease the magnitude of these characteristics. None of these treatments, however, completely attenuate DOMS[7,9,10]. Studies also reported that sports massage reduces DOMS and CK when administered 2 hours after the termination of eccentric exercise[11].

Present clinical practice, cryotherapy and ultrasound therapy are used as the focal point for the immediate management of musculoskeletal injuries. The objectives of the current study were to track the efficacy of ultrasound, cryotherapy and its combination on CK levels, PMS, and rEFA during DOMS.

MATERIALS AND METHODS

The current study approved by the Institutional Ethics Committee, a total thirty healthy subjects of 15 males and 15 females with a basic characteristic of 22.1 ± 5.9 years of age, 169.5 ± 10.3 cm of height, and weight of 62.8 ± 19.5 kg. None of the subjects had performed upper body weight training within the last 6 months, experiencing any musculoskeletal injury and pain, under any medication and phases of the menstrual cycle. The present study was obtained ethical committee clearance from the parent organization. Each subject was clearly explained about the DOMS-inducing exercise protocol and informed written consent was also collected from all the subjects prior to the study. Subjects were randomly allocated into three groups A, B and C (n=10) with equal gender distribution. Each group received different treatment application i.e ultrasound (US), cryotherapy (CT) and combination (C) of both with respective to their group. After completing the pre-exercise evaluation by the investigator and self arm stretching by each subject then asked to perform an exercise of elbow flexors to induce DOMS by eccentric exercises in non-dominant arm. Subjects began with a 13.5-kg (30-lb) dumbbell. Beginning in full elbow flexion, subjects were instructed to lower the dumbbell to full extension over 3 seconds. Upon reaching full extension, the investigator assisted the subjects in returning the weight to the starting position. Subjects performed continuous repetitions until they could no longer control the weight during the 3-second period. At this point, the weight was reduced by 2.25 kg (5 lb), and the protocol was repeated. As subjects continued to fatigue, the weight was sequentially lowered in 2.25-kg (5-lb) increments until a total weight of 2.25 kg (5 lb) was reached. At this weight, subjects were asked to perform repetitions either to fatigue or until 10 repetitions completed. Treatment was applied (respective to their groups). On successive 24 hours interval treatment was repeated. Cryotherapy was given by ice bag (crushed ice) method. Ice crushed and filled in the polythene bag. One layer of towel wrapped around the ice bag to avoid direct contact of skin to the bag. Cryotherapy was

applied for 20 minutes continuously. Pulsed ultrasound treatment with frequency of 1 MHz, duty cycle of 20%, ratio 1:4, intensity of 0 .8 w/cm^2, was given on the muscle belly for 7 minutes. Treatment head of 3cm diameter is used for the treatment. Ultrasonic gel is used to as transmission medium. In combination therapy, cryotherapy was given for 10 minutes, and then pulsed US applied for 4 minutes with five minutes of interval after cryotherapy. Study outcomes were measured by Perceived Muscle Soreness (PMS), Relaxed-Elbow flexion angle (rEFA), Plasma Creatine Kinase (CK) level at 0 hours (pre-exercise), 24hrs, 48hrs, 72hrs and at 92hrs.

RESULTS

Data analysis of outcome variables was done with the help of one-way ANOVA, post hoc test, and Chi-square test for all three groups named as Group A–U. S, Group B–Cryo, and Group C–Cryo +US (**Table:4 and 5**). After 96 hours of post exercise statistical analysis using one-way ANOVA indicated significant differences (p=. 001) between all three treatment groups, with maximum recovery in C Group. Results showed a rise in the plasma CK level at successive level in the three different treatment groups, although the minimal rise in the C Group **(Table:1; Figure:1.)**. After 96 hours of post-exercise analysis showed significant difference (p=.000) between the plasma CK levels of three different groups. PMS value was higher in the Group-A and this value was peak during the 24-48 hours of post-exercise, although there was least increased in the value in the Group-C and it reached toward near normal level at 96 hours of post exercise in C group **(Table:2; Figure:2.)**. **rEFA** value was again higher in the Group-A and this value was peak during the 24-48 hours of post-exercise in A group, although there was least increased in the Group- B and C and it reached toward near normal level at 96 hours of post exercise in C group **(Table:3; Figure:3.)**.

Table.1: Plasma CK level (IU/L) in groups at different time interval

Groups	0Hrs.	24 Hrs.	48Hrs.	72Hrs.	96Hrs.
G-A	149.0±10.9	880.6±90.7	1520.6±72.0	1784.2±94.8	2010.6±88.7
G-B	150.1±10.5	805.6±96.5	1487.8±76.6	1684.4±88.5	1796.2±90.0
G-C	145.0±15.6	685.8±67.9	1276.4±65.9	1467.0±92.2	1547.0±96.4

Table: 2. PMS (cm) level in groups at different time interval

Groups	0Hrs.	24 Hrs.	48Hrs.	72Hrs.	96Hrs.
G-A	0.0±0.0	3.4±0.52	3.4±0.52	2.6±0.51	1.6±0.69
G-B	0.0±0.0	2.6±0.69	2.3±0.48	1.4±0.48	0.5±0.52
G-C	0.0±0.0	2.5±0.50	2.1±0.31	1.1±0.31	0.3±0.48

Table: 3. rEFA (degrees) in groups at different time interval

Groups	0Hrs.	24 Hrs.	48Hrs.	72Hrs.	96Hrs.
G-A	14.1 ±1.4	20.0±1.9	20.1±2.0	18.4±1.5	16.4±1.5
G-B	14.0±1.6	18.1±1.1	7.6± 0.8	16.2±1.0	15.2±1.2
G-C	13.4±1.5	17.0±1.4	7.6± 0.8	14.8±1.1	13.9±1.1

Table: 4. rEFA and Plasma CK level within and between groups

One-way ANOVA Post 96 hrs.		Sum of Squares	df	Mean Square	F	Sig.
rEFA	Between Groups	31.27	2	15.63	9.00	.001
	Within Groups	46.90	27	1.74		
	Total	78.17	29			
	Between Groups	1076643.20	2	538321.60	51.63	.000
CK	Within Groups	281526.00	27	10426.89		
	Total	1358169.20	29			

Table: 5. PMS analysis in groups

Chi-Square Tests	Value	df	Asymp.Sig (2-sided)
Pearson Chi-Square	19.000(a)	4	.001
Likelihood Ratio	23.755	4	.000
Linear-by-Linear Association	14.586	1	.000
N of Valid Cases	30		
A 9 cells (100.0%)have expected count less than 5. the minimum expected count is 2.00			

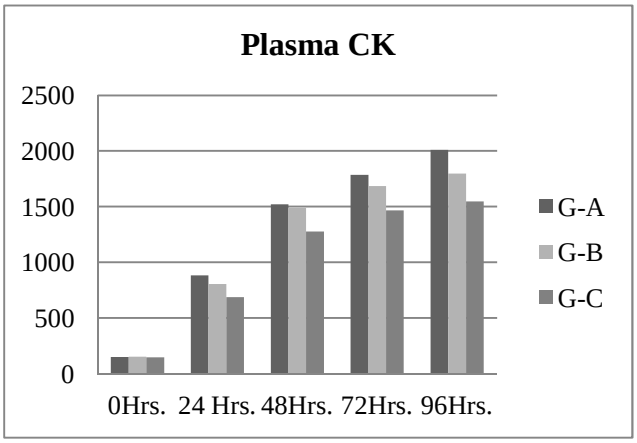

Fig:1. Plasma CK level in groups at different time interval

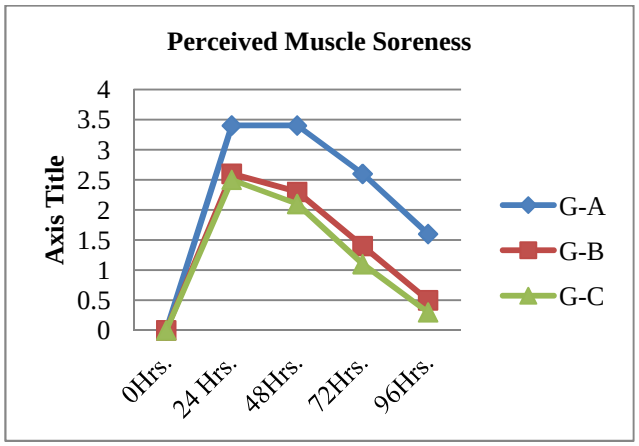

Fig:2. PMS level in groups at different time interval

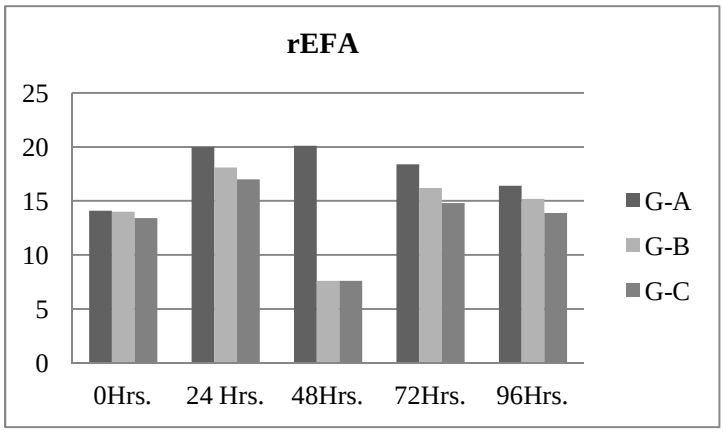

Fig:3. rEFA in groups at different time interval

DISCUSSION

The objectives of the present study was to track the efficacy of ultrasound, cryotherapy and its combination on CK levels, PMS, and rEFA during DOMS. The treatment of cryotherapy and pulsed ultrasound therapy immediately after exercise induced muscle damage is effective in reducing stiffness as relaxed arm angle, and reduction in muscle soreness level, and lower value of plasma CK activity. In the current study all three groups' results showed improvement with respect to their interventions, whereas the C group, after 96 hours of exercise the rEFA return to its near normal range as compared to the other two groups. Although there was a rise in the plasma CK level in all three groups, however the C group was effective in minimizing the rising level of CK at 96 hours of post-exercise and the muscle soreness was reduced significantly in both B and C groups and reached almost to baseline after 96 hours of post-exercise.

The present study used pulsed US as an intervention and its positive effects on the results were supported by the mechanical effects, stable cavitations, and micro streaming are believed to aid tissue regeneration and healing[8]. Acoustic micro streaming and cavitation increase the diffusion of ions and metabolites across the cell membranes and enhance the reparative process[12]. Changes in calcium permeability are associated with enhanced tissue healing[12]. Increased sodium permeability may reduce pain and spasm by altering neural activity[12]. In the current study these factors might have improved the muscle soreness.

Until little researches have been performed on rEFA and its role with pulsed US, Cryo therapies. Continues US with its thermal effect was normally used to increase range of motions[13]. In the previous studies also observed that any reduction of significant evidence of perceived soreness and relaxed elbow angle indicates healing and treatment effect. Our finding also supports with the data from US alone treatment for an acute inflammation response is effective for DOMS[8]. Elbow range of motion was actually a function of subjective soreness in this study. Subjects were asked to actively extend the elbow to physiological limitation or to pain tolerance. Because no subject recovered full extension (relative to pretest values) by 96 hrs, pain undoubtedly played a role in rEFA. Joint stiffness and decreased mobility are common following muscle injury, and movement may be more discouraged by the stiffness than by pain, but the subjects were extending the elbow to the point that any further extension would be too painful; thus, rEFA was an indicator of how much pain subjects were experiencing.

Studies indicated the positive results of cryotherapy with pulsed ultrasound in the treatment of acute muscle injuries and pulse ultrasound therapy helped in regeneration of muscle fibers, which ultimately reduce the healing time[8,13,14]. In case of muscle soreness combined therapy almost improved the muscular function by means of near normal relaxed arm angle and with minimal muscle pain. However in the case of plasma CK level, there was minimal raised in the value of combined group as compared to the other two groups, but failed completely to decrease in the value at successive time interval.

CK levels depend on age, gender, race, muscle mass, physical activity and climatic condition[15]. High levels of CK in apparently healthy subjects may be correlated with physical training status, as they depend on sarcomic damage; strenuous exercise that damage skeletal muscle cells results in increased CK total CK activity is markedly elevated for 24 hours after the exercise bout[16]. Although previous researches indicated that it was not a good indicator of DOMS because it varies with many possibilities and sometimes it

did not relate to other symptoms of DOMS. Pulsed ultrasound therapy helps in the regeneration of skeletal myofibers after DOMS. By reducing the symptoms of DOMS this study indicated that if deep temperature at tissue level was reduced and pulse ultrasound used without heating effect it can facilitate the recovery of muscle soreness and regeneration of muscle fibers[17]. A study suggested that sports massage will reduce DOMS and CK when administered 2 hours after the termination of eccentric exercise. This may be due to a reduced emigration of neutrophils and/or higher levels of serum cortisol[11,] the micro massage effect of US also contributed to the positive result.

Gulick et al. (1996) was reported that there was decreased in the muscle soreness level in the cryotherapy group after treatment and on the next day and stated that was because of numbing effect of cold modality depress the excitability of the free nerve ending and peripheral nerves which increases the threshold and decreased pain. This was proved in previous studies as they measure local pain thresholds after treatment with ice give varying results, with the effects lasting from 30 minutes to 12 hours. Cold also slows the conduction velocity of peripheral nerves[18].

In our study observed the effect of pulsed ultrasound therapy and cryotherapy individually and in its combination form by reducing the symptoms of DOMS. It is also observed It is also observed that cryotherapy was more effective than pulsed ultrasound alone treatment in reduction of symptoms. Studies also proved immediate application of cryotherapy reduced the tissue temperature as well as the demand of oxygen at injured cell. This helps in the minimizing secondary damage to muscle due to hypoxia and increased in temperature. And if there is less damage to muscle and less edema formation at the cellular level, recovery will be easy as compared to high temperature at tissue level. This effect of cryotherapy was supported in the past studies as they provide evidence for secondary injury in tissue due to exercise induced muscle soreness and effective way of treatment[19,20].

CONCLUSION

The combined application of cryotherapy and pulsed US immediately after exercise induced muscle damage, was effective to reduce the symptoms of DOMS and it facilitated the tissue healing. It is also observed that cryotherapy was more effective than pulsed ultrasound alone treatment in reduction of symptoms. This showed through the reduction in the presence of symptoms and their severity. Only plasma CK level showed persistent increased in all groups at successive intervals. Although that was least raise in the cryotherapy with a pulse ultrasound group, but this group also unable to completely decrease the persistent increase in CK level. It helps in maintaining the plasma CK level at minimal value compared to other two groups. So if cryotherapy with pulse ultrasound used in appropriate methods it will show positive results in the reduction of symptoms of DOMS.

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