Effectiveness of pulsed ultrasound and cryotherapy on delayed onset muscle soreness

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Purpose of the Study: Delayed onset muscle soreness (DOMS) is defined as the sensation of discomfort or pain in the skeletal muscles following physical activity, usually eccentric, to which an individual is not accustomed. DOMS begins usually 8–24 h after exercise in which pain, soreness, swelling, and stiffness and muscle spasm and peaks after 24–72 h. Cryotherapy and pulsed ultrasound were common modalities used to treat the DOMS effectively. Hence, this study is intended to compare the effect of these modalities on DOMS.

Materials and Methods: Normal healthy individuals (n = 32) of age group between 18 and 30 years was selected randomly and divided into two groups. Group A received pulsed ultrasound therapy and Group B received cryotherapy. The total duration of the study was three sessions for 3 consecutive days. Measurements are taken initially before receiving the interventions and at the end of every treatment session by using universal goniometer for measurement of range of motion (ROM) and visual analog scale for pain. Data thus collected were analyzed and recorded for the study.

Results: Mean ROM in Group A who received pulsed ultrasound is 143.42 and Group B who received cryotherapy is 140.12 and showed that there is an induction of DOMS. When comparison of pulsed ultrasound over cryotherapy shown a significant P < 0.05.

Conclusion: Both pulsed ultrasound and cryotherapy are almost equal with each other up to a period of 48 h. However, pulsed ultrasound has an additional effect of increasing the ROM on day 3 onward when compared to cryotherapy.

Key words: Cryotherapy, delayed onset of muscle soreness, pulsed ultrasound

ABSTRACT

أثر الموجات الصوتية النابضة والعلاج بالتبريد في تأخير حدوث آلام العضلات

خلفية الدراسة: تأخير حدوث آلام العضلات (DOMS) يعرف بالاحساس بعد عدم الراحة أو الالام في العضلات المخططة بعد الانشطة الجسدية وتكون آلمًا غير معتمدة وفي العادة يبدأ ظهور الآلام العضلات بين 8–24 ساعة بعد التمرين حيث أن الآلم والتورم والتقرح والتصلب والتغلب يصل زروته ما بين 24–72 ساعة. بعد العلاج بالبرد للموجات الصوتية النابضة وسيلة علاجية شائعة تستخدم علما يحدث التأثير في حدوث الآلام العضلات.

هدف هذه الدراسة: المقارنة بين تأثير هذين العلاجين في تأخير حدوث الآلام العضلات المخططة.

المواد والطرق: تم اختيار مجموعة من 32 فرد طبيعيين تراوح اعمارهم بين 13-30 عاماً عشوائياً وتم تقسيمهم إلى مجموعتين: المجموعة (A) تلقّت علاجًا الموجات الصوتية والمجموعة (B) تلقّت علاجًا بالتبريد. وكانت الفترة الزمنية للدراسة 3 جلسات لمدة 3 أيام متتالية. أخذت القياسات (Rom) قبل تلقي التدخلات في نهاية كل جلسة علاجية باستخدام اجهزة قياس عالمية لدّى الحركة.

ومقياس المباشرين البصري للالم هكذا تم جمع المعلومات لتحريها وتسجيلها للدراسة.

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INTRODUCTION

Delayed onset muscle soreness (DOMS) is defined as the sensation of discomfort or pain in the skeletal muscles following physical activity, usually eccentric, to which an individual is not accustomed.[1] DOMS begins usually 8–24 h after exercise in which pain, soreness, swelling, and stiffness and muscle spasm and peaks after 24–72 h.[2] Any activity in which the muscle produces higher forces than usual or produces forces over a longer time period than usual can cause DOMS. The degree of muscle soreness is related to both the intensity of the muscular contractions and the duration of the exercise. The intensity seems to be more important in the determination than the duration.[3]

The sensation of DOMS is carried primarily by Group IV afferent fibers. The free nerve endings of Group IV afferent fibers in muscles are polymodal and respond to a variety of stimuli including chemical, mechanical, and thermal. Chemical substances that elicit action potentials in muscle Group IV fibers in order of effectiveness are bradykinin, 5-hydroxytryptamine (serotonin), histamine, and potassium.[4]

Structural damage from high tension was the hypothesis originally was proposed by Hough and is the most scientifically accepted theory. The delayed pain was related directly to the peak forces developed and to the rate of force development in rhythmic contractions. DOMS was not related to the state of fatigue of the muscle. The rhythmic and tetanic contractions causes the acute fatigue and discomfort in the muscles during the exercise resulted in the least delayed pain following the exertion.[1]

Metabolic waste product accumulation is one of the most popular concepts which explained that delayed soreness is a result of lactic acid accumulation in the muscles. The degeneration and regeneration of muscle fibers observed after 2–3 h of ischemia, which results from exercise-induced injury. Exercise involving eccentric contractions requires lower oxygen consumption and produces less lactate than exercise with concentric contractions at the same power output.

Lower oxygen uptake produces less lactic acid level results DOMS.[5]

Spastic contracture is also a result of altered nerve control and vasoconstriction leads to decrease blood flow and ischemia, which in turn initiates a pain-spasm-pain cycle. The magnitude of pain is dependent upon the number of motor units involved and may lead to DOMS.[6]

Myofibril and cytoskeleton alterations are considered to be the hallmarks of DOMS and reflect adaptive remodeling of the myofibrils which include the following changes such as amorphous widened Z-disks, amorphous sarcomeres, double Z-disks, and numerous sarcomeres.[7]

Cryotherapy and pulsed ultrasound were common modalities used to treat the DOMS. Bleakley et al. did a study on 30 subjects and showed that effect of ice was effective in acute soft muscle injuries. Cold also decreases the activity of cells to reduce swelling and internal bleeding at the site of acute injury; it is best used in the first 48 h after an injury. Cooling the deep tissue also reduces muscle spasm by reducing the muscle's ability to maintain a contraction. He also stated that more high-quality trials are needed to provide evidence-based guidelines in the treatment of acute soft-tissue injuries.[7]

Paddon-Jones and Quigley done a study to determine the effect of cryotherapy recovery on elbow flexor strength and reduce the severity of DOMS following eccentric exercise on eight resistance-trained males. The results suggested that the use of cryotherapy immediately following eccentric exercise and it was very effective in reducing DOMS.[8]

The other modality which plays a key role in the management of DOMS is pulsed ultrasound. It can be useful in speeding up the healing process of injured tissues. Ultrasound travels into the damaged tendons and muscles, causing the molecules to collide, resulting in a deep heating effect. This thermal reaction causes increased metabolic activity and vasodilation of the blood vessels, allowing for more nutrients and oxygen to reach the damaged tissues while washing away many of the pain producing chemicals. The thermal effects
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of ultrasound decrease pain of the damaged tissues. [9] Craig et al. reviewed that application of ultrasound on DOMS has an earlier and significant effect on improving range of motion (ROM). [10] Ciccone et al. also reviewed the effects of ultrasound on DOMS. Repeated eccentric contractions were used to induce DOMS in the elbow flexors of 40 college-aged women and his findings suggested that the use of pulsed ultrasound had a significant little effect on treatment of DOMS.

A visual analog scale (VAS) is a measurement instrument used to measure a characteristic or attitude that is believed to range across a continuum of values and cannot easily be directly measured. The amount of pain that a patient feels was categorized as none, mild, moderate, and severe. Operationally, a VAS is usually a horizontal line, 100 mm in length, anchored by word descriptors at each end. The patient marks on the line the point that they feel represents their perception of their current state. The VAS score is determined by measuring in millimeters from the left-hand end of the line to the point that the patient marks. [11] Kelly also set-up VAS as a measuring tool to find the clinical significance in pain score. [12]

Both pulsed ultrasound and cryotherapy have a significant effect on DOMS. Therefore, this study is intended to compare the effects of these modalities on DOMS.

**Aims of study**
- To find out the effectiveness of pulsed ultrasound therapy on ROM and pain in DOMS
- To find out the effectiveness of cryotherapy on ROM and pain in DOMS
- To compare the effectiveness of pulsed ultrasound versus cryotherapy for improving the ROM and reduction of pain in DOMS.

**MATERIALS AND METHODS**

**Sample selection**
In this study, normal healthy individuals (n = 32) of age group between 18 and 30 years was selected randomly and divided into two groups, 16 in each group. An informed consent form was taken from all participants.

**Materials used**
- Pulsed ultrasound
- Ice cubes
- Dumbbell (5 kg)
- Universal transparent goniometer
- VAS scale.

**Inclusion criteria**
- Subjects who are willing to participate in the study
- Subjects capable of understanding instructions given by the therapist
- Subjects with no pre- and past-history of injury to upper extremity.

**Exclusion criteria**
- Subjects having any surgical history of upper extremity
- Any elite level athletes
- Subjects underwent chemotherapy.

**Procedure**
The 32 subjects are divided into two groups 16 in each group and DOMS are induced in nondominant biceps muscle using 5 kg dumbbell until pain is induced.
- Group A: Each subject received pulsed ultrasound treatment of intensity 0.8 W/cm² for 7 min
- Group B: Each subject received cryotherapy for 10 min.

The total duration of the study was three sessions for 3 consecutive days. Measurements are taken initially before receiving the interventions and at the end of every treatment session by using universal goniometer for measurement of ROM and VAS scale for pain. The data thus collected were analyzed and recorded for the study.

**RESULTS**

Mean and standard deviation of pulsed ultrasound and cryotherapy on ROM after the end of 3 days treatment session are 143.42, 2.89 and 140.12, 4.19. Mean and standard deviation of pulsed ultrasound and cryotherapy on pain scale after the end of 3 days treatment session are 1.54, 0.56 and 1.87, 0.59. Comparison of both these modalities in relation to ROM and pain scale showed a significant value on DOMS (P < 0.05). Statistical significant tests are summarized in Tables 1-7. Graph 1 shows the effect

**Table 1: Effectiveness of Ultrasound on ROM - Group A**

<table>
<thead>
<tr>
<th>Days</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre exercise, Post ex - Day 0</td>
<td>143.7, 138.21</td>
<td>2.83, 4.71</td>
<td>0.55, 0.92</td>
</tr>
<tr>
<td>Pre treatment, Post treatment - Day 1</td>
<td>133.1, 138.71</td>
<td>4.49, 266</td>
<td>0.91, 0.36</td>
</tr>
<tr>
<td>Pre treatment, Post treatment - Day 2</td>
<td>133.9, 135.94</td>
<td>6.76, 6.22</td>
<td>1.36, 1.24</td>
</tr>
<tr>
<td>Pre treatment, Post treatment - Day 3</td>
<td>135.7, 143.42</td>
<td>5.49, 2.89</td>
<td>1.04, 0.58</td>
</tr>
</tbody>
</table>

**Table 2: Effect of Ultrasound on pain scale - Group A**

<table>
<thead>
<tr>
<th>Days</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post exercise, - Day 0</td>
<td>4.24</td>
<td>0.69</td>
<td>0.14</td>
</tr>
<tr>
<td>Pre treatment, Post treatment - Day 1</td>
<td>4.72, 3.74</td>
<td>0.66, 0.90</td>
<td>0.13, 0.16</td>
</tr>
<tr>
<td>Pre treatment, Post treatment - Day 2</td>
<td>4.30, 3.04</td>
<td>0.83, 1.01</td>
<td>0.16, 0.22</td>
</tr>
<tr>
<td>Pre treatment, Post treatment - Day 3</td>
<td>3.56, 1.54</td>
<td>0.92, 0.56</td>
<td>0.17, 0.12</td>
</tr>
</tbody>
</table>
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of pulsed ultrasound and cryotherapy on pain scale after 3 days of the treatment session.

**DISCUSSION**

DOMS is a condition characterized by soreness, swelling, and pain with decreased ROM at both early and late stages usually occurs following by unaccustomed activity or an eccentric muscle activity in an individual. Normally, the acute soreness occurs in muscles at the time of activity, whereas DOMS is seen after 24 h. The symptoms of DOMS commonly occur in sports persons, which should be intervened effectively before the performance of the athlete is affected.

There are many therapeutic exercises and electrophysical treatments available for treatment of DOMS. Cryotherapy and pulsed ultrasound are most commonly used modalities in sports injuries. Many researches found the effectiveness of ultrasound and cryotherapy on DOMS, but the comparison of the both modalities has been not analyzed. Therefore, the main aim of this study is to find out the comparison of pulsed ultrasound versus cryotherapy on DOMS. Analysis showed that there is significant difference between the treatments days by using both pulsed ultrasound and cryotherapy treatments.

The study was conducted on 32 individuals with two groups of 16 each. Group A received pulsed ultrasound and Group B received cryotherapy. The output parameters, i.e., the ROM taken by using universal goniometer and pain score by using VAS scale was measured from day 0 to day 3 posttreatments, where the result were significant at $P < 0.05$.

The present study also finds the effectiveness of pulsed ultrasound and cryotherapy on ROM following DOMS. Daywise comparison was made between groups and significant difference was found between the two groups.

The mean ROM, i.e., 138.21 in Group A who received pulsed ultrasound and 137.81 in Group B who received cryotherapy following eccentric exercise showed that there is an induction of DOMS. When compared with their pre-exercise values that are 143.71 and 144.72. This result shows that the effectiveness of pulsed ultrasound and cryotherapy are almost equal with each other up to a period of 48 h. However, the pulsed ultrasound has an additional effect for increasing the ROM on the day 3 onward.[13]
The present study also finds the out the effectiveness of pulsed ultrasound and cryotherapy on pain following DOMS. Both the modalities were compared using Mann–Whitney test and the mean rank scores of pain scale of pulsed ultrasound and cryotherapy on postexercise day 1 are 28.16 and 24.01, and there is no pain prior to induction of DOMS which shows muscle soreness was induced by eccentric protocol. The mean values of both pain groups when compared with pulsed ultrasound and cryotherapy treatments on pretreatment day 1 and posttreatment day 1, pretreatment day 2 and posttreatment day 2, pretreatment day 3 were not statistically significant, where the comparison of the effectiveness on posttreatment day 3 on pulsed ultrasound and cryotherapy has shown 23.27 and 28.72 values, respectively, of pain score.

Our study also supports the findings of Isabell et al. in which they stated that cryotherapy was effective in increasing ROM decreasing the soreness level and was more effective in reducing pain and restoring ROM. The result of this study also correlates with the findings of the above researchers.[14]

Pain decreases the following cryotherapy may be due to the following factors. They are (a) decrease in conduction velocities of the free nerve endings, (b) decrease in muscle spasm, (c) decrease in excitability of the nerves, (d) decrease in tissue temperature, and (e) vasoconstriction and reflex vasodilatation of the arterioles. Cryotherapy directly and rapidly modifies the sensation of pain by inhibiting pain transmission. The immediate analgesic effect being produced due to soothing effect and thereby stimulates the sensory nerve receptors.[15]

The results showed the effectiveness of pulsed ultrasound and cryotherapy is almost equal up to 48 h. However, pulsed ultrasound treatment mean value shows the a difference in pain scores that decreased on posttreatment day 3 compared to cryotherapy which shows that pulsed ultrasound has a significant effect on further reducing pain up to 72 h than cryotherapy.[16]

Results of this study also support our alternative hypothesis and found that the pulsed ultrasound and cryotherapy have an effect on reducing DOMS. It also supported the hypothesis that ultrasound is more effective in reducing the symptoms of DOMS when compared with cryotherapy. Pulsed ultrasound shows that there is an increase in ROM and decrease in pain score at 72 h posttreatment period. The causes may be a less inflammation and less pain, less fluid filtration, and decrease in metabolic rate. Application of pulsed ultrasound increases calcium levels, which alters the enzymatic activity of cells and their synthesis and secretion of proteins.[16] From this study, it can be stated that pulsed ultrasound is effective for treating DOMS than cryotherapy.

CONCLUSION

The groups received pulsed ultrasound and cryotherapy treatment showed the effects were almost equal up to 48 h. The Group A, who received pulsed ultrasound treatment, did not show a statistically satisfactory results when compared with cryotherapy within 48 h. However, after 48–72 h and later pulsed ultrasound was effective than cryotherapy on DOMS.

As both the groups has shown increase in ROM and decrease in pain following induced DOMS within 72 h. From the study, it shows that pulsed ultrasound can be used as methods of choice for the treatment of patients with DOMS than cryotherapy.

**Areas of further research**

- As this study was done on the normal individuals, further studies are suggested to detect the progress in patients
- In this study, the subjects received exercises only on nondominant hand, as strength is not bilaterally symmetrical. Further studies should be done by inducing DOMS to both hands
- As this study was done on male subjects, further studies can be done on female subjects by inducing DOMS and identifying their response to this treatment approach
- In this study, 5 kg dumbbell was used; therefore, further studies should be done by using different weights of dumbbell.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**