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Is Low Level Laser Therapy Effective for the Treatment of Delayed Onset Muscle Soreness

Rachel Deppa
The College at Brockport, rdepp1@u.brockport.edu

Is Low Level Laser Therapy Effective for the Treatment of Delayed Onset Muscle Soreness

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By
Rachel Deppa
Athletic Training Major

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Thesis Director: Dr. Timothy Henry, Director, Athletic Training Program, Associate Professor, Department of Kinesiology, Sports Studies, and Physical Education

Introduction

Delayed onset muscle soreness, better known as DOMS, is pain or discomfort associated with muscle damage. DOMS is a common syndrome experienced by recreational and elite athletes, as well as those in the fitness world. DOMS may be caused by unaccustomed exercise or the introduction of a new level of exhaustive exercise.[3] Eccentric exercise, in particular, causes more intense DOMS than concentric or isometric contractions.[7] It is hypothesized that fewer motor units are recruited during eccentric exercise, which causes a higher degree of stress placed on those fibers and a greater degree of damage.[4] DOMS is most commonly characterized by pain, swelling, and loss of muscle function including decreased range of motion (ROM) and strength deficits. Pain will intensify during the initial 24 hours following exercise, peak between 24 and 72 hours, and subside within the following 5-7 days.[4]

DOMS causes muscle damage at the tissue and the cellular level. The early stages of muscle damage are accompanied by the inflammatory process. Leukocytes move out of the blood to infiltrate the damaged tissue and proteins such as myoglobin (Mb) are released into circulation. Neutrophils enter the blood stream to migrate and accumulate in the damaged tissue to begin cleaning out the area. Neutrophils are replaced by macrophages in the first 24 hours, which activates inflammatory cells to continue removing debris and start remodeling of the tissue.[3]

Clinicians have used many recovery strategies to attempt to minimize the negative side effects of DOMS. Traditional methods include ice, stretching, massage, NSAIDS, electrical stim, etcetera. More recently low-level laser therapy, or laser, has been introduced as another treatment option. Laser, which stands for light amplification by stimulated emission of radiation, was discovered in 1960 and has since been used for promoting healing of wounds, deeper tissue, and nerves; reducing pain and treating neurological disorders; and decreasing inflammation, edema, and chronic joint disorders.[2] Therapeutic lasers are referred to as “cold lasers” due to the fact that they use power densities lower than those needed to produce heating of the tissue.[2] Lower doses of light are used because they are often more effective at increasing physiologic activity. As described by the Arndt-Schulz law, higher doses decrease or totally stop the physiologic activity in the tissues.[2] The low power density and low doses used with LLLT makes it possible to avoid causing tissue destruction like other lasers do. Therefore, laser application can be safe for clinical use.[10]

Light is part of the spectrum of electromagnetic radiation, which has a dual nature of both particles and waves. The particles, known as photons, are pockets (quanta) of energy that move at the speed of light. The energy contained in each photon determines the color of the light emitted.[2] Chromophores, which are certain skin receptors found in mitochondria, will absorb light photons with specific colors and use the light’s energy to elicit physiological events in the tissues.[2, 10] Biological events at a tissue and cellular levels are not totally understood yet, but there is evidence suggesting that effects include: temporarily increasing local blood circulation; increasing mitochondrial products including adenosine triphosphate (ATP), NADPH, and RNA; increasing tissue oxygenation; and upregulated cellular respiration.[2, 12] Blood circulation is increased by triggering relaxation of smooth muscle, therefore allowing vasodilation of local blood vessels. This allows increased oxygen to the damaged tissues and increased transport of immune cells to the tissue.[2] Therefore, laser amplifies the inflammatory process initiated by DOMS, which further increases the infiltration of leukocytes into the damaged tissue, enhances fibroblast and macrophage activity, and increases motility of epithelial cells allowing wound sites to heal more quickly.[2] Pain reduction through laser is achieved by altering the nerve conduction velocity, decreasing muscle spasm, and releasing pain inhibiting substances including endogenous opiates.[10]

Ice and stretching is a classic, and widely used, treatment for DOMS. Hydrotherapy is a favorable option for icing because it affects a larger surface area compared to other thermal modalities.[11] Cold whirlpool, a method of hydrotherapy, is a form of superficial cooling that consists of the external application of cold water to the body.[3, 4] Heat is transferred from the cooler surface (water) to the warmer surface (body) through the exchange of kinetic energy.[11] Cold whirlpool is set at a temperature between 55-65 degrees Fahrenheit and applied for 20 minutes.[9] Sensations that the patient feels while immersed in the cold whirlpool include cold, burning, aching and finally numbness. A primary benefit of cold application is the reduction in cell metabolism, which will decrease the area of secondary hypoxic injury around the damaged tissue.[11]

Another benefit of ice is its ability to suppress the inflammatory process. Edema is the result of increased permeability of blood vessels that allows excess exudate to escape into the damaged tissue.[4] Cold application decreases the release of inflammatory mediators and causes vasoconstriction in the vessels. This will reduce the amount of hemorrhage and edema accumulation in the tissue.[4, 11] Limiting edema is a primary method for pain control because it decreases mechanical triggers on the nerves.[11] Analgesic effects of cold are also partially due to interruption of nerve transmission directly at the application site. Nerve conduction velocity will decrease as the depolarization threshold required to initiate the impulse increases. The combination of these two effects will greatly decrease the transmission of pain from superficial nerves at the site of cold application. For cold to have effects on the deeper nerves, the cold application must be done for a longer period of time.[11]

Reducing pain will not only provide temporary relief for the patient, but also lead to decreases in muscle spasm. When the excitability and conduction velocities of the nerves are decreased it will lessen the amount of spasm experienced in the tissue. The response of Golgi Tendon Organs is also reduced as a result of cold application, allowing for muscle relaxation.[4] Deficits in range of motion will also be minimized by cold application secondary to decreased edema in the joint space and diminished muscle spasm.[4, 9] Combining the effects of ice with stretching will further increase motion in the affected muscle and joint.

Many researchers have studied DOMS and the potential treatment options for the syndrome, but results continue to be inconsistent. Cold whirlpool with stretches is a common method to reduce the signs and symptoms of DOMS and has been a topic of study for many years. Results have been varied, leaving clinicians still wondering if it is a superior or misbegotten treatment. As a somewhat newly introduced treatment, the effects of LLLT on DOMS has been minimally studied. The potential for success of LLLT is there, but little has been proved at this point to make clinicians comfortable with using the modality as treatment for DOMS.

The purpose of this investigation was to determine the efficacy of LLLT on the bicep brachii of subjects suffering from DOMS, as defined by variables of perceived pain, active elbow flexion, and active elbow extension. Objectives also included comparing LLLT to other traditional treatment methods for DOMS, such as ice immersion and stretching, and adding to the body of research on LLLT. The independent variable was represented by the three different treatment groups; ice and stretch, LLLT, and placebo.

Methods

Subjects

Thirty volunteer male and female college-aged students from The College at Brockport participated in this study. These students were in the age range of 18-30. Students who have majors in the KSSPE Department and/or athletes at SUNY Brockport were recruited to participate. All participants were free of upper limb injuries and contra-indications to cold. All participants refrained from upper body weight training 3 days prior to and 5 days after the initial induction of DOMS. Other forms of training such as aerobic and lower extremity training were permitted. All subjects were informed of possible risks and benefits before signing an informed consent from. The form was approved by SUNY Brockport's Institutional Review Board prior to the start of the study. Subjects were educated that the only treatment they could obtain for DOMS while in the study was the one instructed by the researchers. Treatments other than those specified by their group, including medications such as NSAIDS, were not permitted.

Measurements

Three measurements were taken daily for a total of 5 days at the assessment times of: baseline (before DOMS induction), hour 0 (directly after DOMS induction & first treatment), hour 24, hour 48, hour 72 and hour 96 post exercise.

Range of Motion

Elbow range of motion (ROM) was measured as a primary means for assessing elbow integrity and evaluating the level of impairment post DOMS induction.[6] ROM measurements were taken using a plastic universal goniometer which is a simple, easy to use instrument that has been found to be both reliable and valid.[4,6] To take consistent measures the goniometer was centered on the lateral epicondyle, the stationary arm was pointed at the tip of the acromion process, and the mobile arm was positioned at the radial styloid process.[6] Extension for the average person is around 0° and flexion is about 150°.[6] In this study, ROM measures of active flexion and active extension were used as investigative tools to track treatment effectiveness.

Perceived Pain

The Numeric Rating Scale for Pain (NRS) was used to measure pain severity. The NRS was chosen to use because of its simplicity. Pain, described as "an unpleasant sensory and emotional experience" that is "always subjective", is most often the primary complaint of suffering and disruption in normal life for patients.[1] The NRS consists of a horizontal bar marked with whole numbers from 0-10, with 0 being no pain and 10 being the worst pain imaginable. The patient is asked to rate where on the scale their pain level falls and the number is recorded.[5] Pain was measured before the induction of DOMS and subsequently after each daily treatment session. Subjects were told to rate their pain at the exact time the measurement was taken, rather than as an average over the 24-hour time periods.

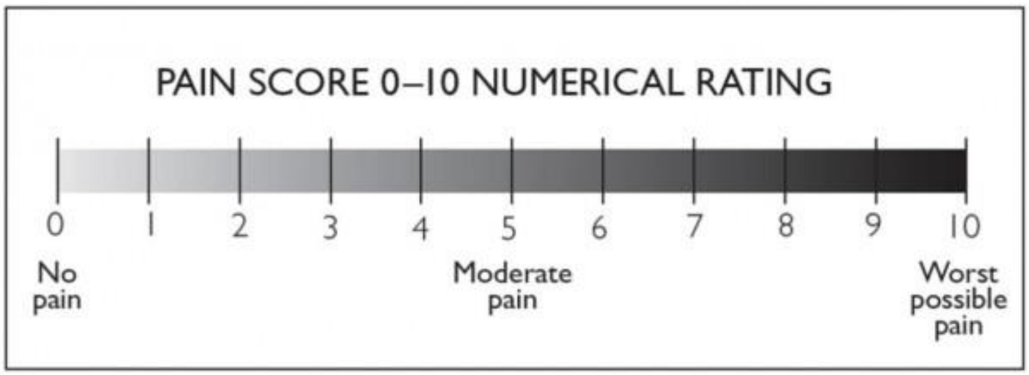

Figure 1: Numeric rating scale for pain used daily to determine the intensity of the participants' pain

<u>Induction of DOMS</u>

Following baseline measurements, DOMS was induced in the forearm flexor muscles of the non-dominant arm of all participants. The protocol used was outlined by Lori A. Kuligowski.[4] Subjects first lifted dumbbells in increasing 5-lb increments to determine a 1-repetition max. The lifting position had subjects standing behind a bench with the upper arm resting on it for support to prevent hyperextension in the elbow. The arm started with the elbow fully flexed and forearm supinated. Subjects then eccentrically lowered the weight to a count of five. The subjects arm and the dumbbell were passively returned to the starting position by the researcher. That cycle continued until either fatigue or 10 repetitions were complete. If fatigue occurred first, 5lbs was removed so the subject could finish the full 10 repetitions. After a set was completed, a 1-minute rest period was given before the subjects began the next one. Five sets, totaling 50 repetitions, were completed by each subject, lowering weight as needed.

Treatment Protocol

Subjects were randomly assigned to 1 of the 3 treatment groups, consisting of ice & stretch, LLLT, and a placebo treatment. The ice and stretch group first submerged the DOMS arm in a cold whirlpool (55-65°F) for 20 minutes.[9] Each subject sat on a stool next to the whirlpool and lowered the arm into the tub until the water reached a mid-deltoid level and the axilla was resting on the rim of the tub. The subjects relaxed their arm, allowing it to hang freely in the water. Following cold hydrotherapy, the subjects performed three different stretches three times each, holding each for 30 seconds. The stretches included a behind the back stretch, stand & stretch, and wall stretch. For the behind the back stretch, the subjects would clasp their hands behind the back and turn the palms face down. The arms were then raised until tension was felt in the bicep. The stand and stretch had the subject raise the affected arm to 90° of flexion out in front of the body, parallel to the floor, with the palm facing the ceiling. The subjects would extend their wrist, using the other hand to pull the fingers towards the body. The final stretch was the wall stretch in which subjects would stand facing the wall so that they were slightly closer than an arm's length away. They would place the affected arm against the wall with the palm touching the wall and fingers pointed horizontally. Then the body would be twisted away from the arm until a stretch was felt in the bicep.

Subjects placed into the low-level laser therapy group will receive treatment at four locations along the ventral side of the belly of the bicep brachii muscle. Four locations were chosen so that LLLT irradiation could be delivered to most of the surface area of the bicep. The locations included the insertion, origin, and two points in the belly of the muscle that divided it into three sections of equal length. The exact distance of the treatment area varied depending on the size of the participant. Irradiation was performed in contact mode, holding the laser stationary against the skin with slight pressure at a 90° angle. Each location was treated for a duration of 23 seconds.[8] The final group was the placebo group. A sham laser treatment was given to subjects in this group. The laser applicator head was placed on the skin, just as it was in the normal laser treatment, and each location was treated for 23 seconds. However, no light was actually emitted.

Results

Statistical Analysis

The data was first run through SPSS normality testing and no significant outliers or missing data was found. Proving the data was "normal" meant a paired T-test and repeated measures ANOVA test could be run. A separate T-test was done for each group and each parameter measured within the groups. The placebo group showed pain was significant (0.045) and flexion (0.406) and extension (0.696) were not significant.
The ice and stretch group showed no significance with pain (0.068), flexion (0.437) or extension (0.811). And the LLLT group also showed no significance in pain (0.143), flexion (0.624), or extension (0.776). A T-test ran with combined data showed the only significance the modalities had was on pain (0.001). Flexion (0.327) and extension (0.395) were not significant because many patients got close to, but did not fully return to their baseline measures of range of motion. A one-way repeated measures ANOVA was performed to compare the effectiveness of three different therapeutic modalities on flexion, extension, and pain before and after the induction of DOMS. This type of analysis allowed comparisons of the variable measures at baseline to be compared with values at hour 96. Sphericity was not met because the P value of the test was found to be significant. For this reason, the multivariate tests results could not be included. Therefore, the Greenhouse-Geisser Epsilon value was used within the univariate tests to revise our

results. The test within subject effects showed that over time there was no significance between groups in flexion (0.614), extension (0.614), or pain (0.634).

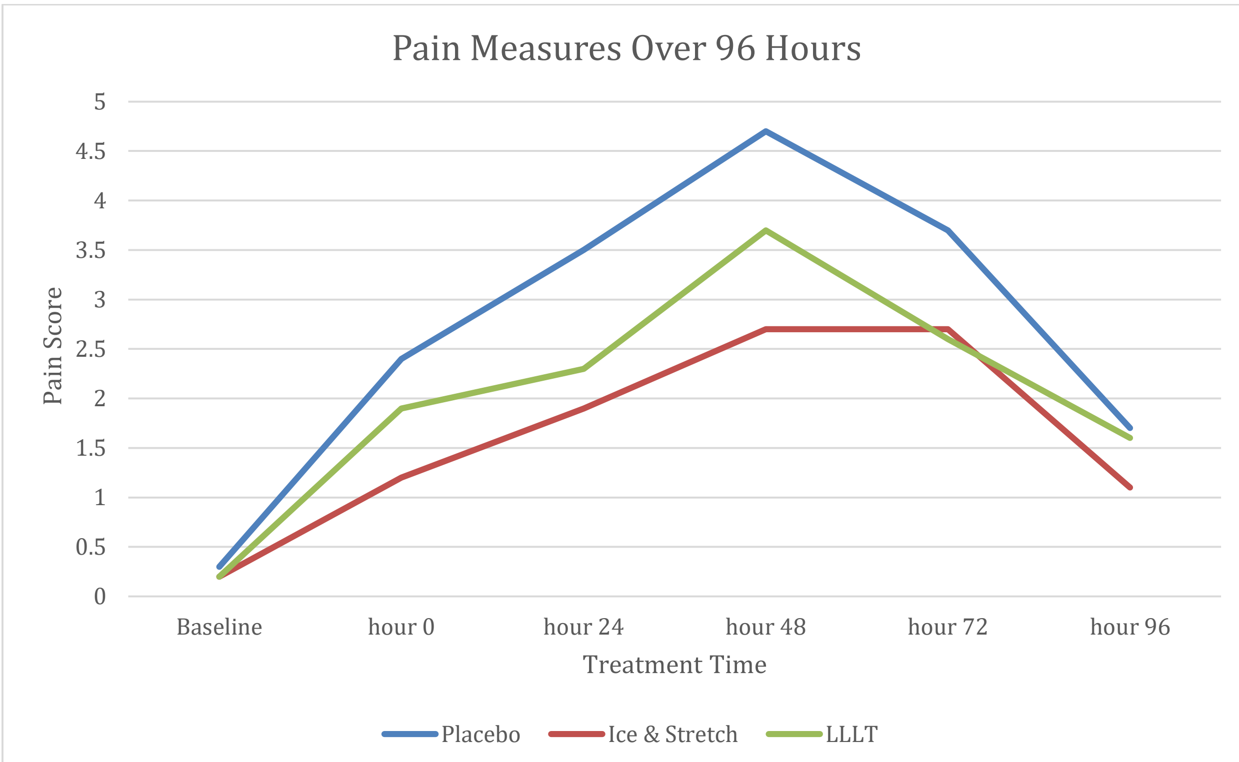

Figure 2: Course of changes in pain associated with delayed onset muscle soreness (DOMS) following the eccentric bicep curl exercise as determined by the numeric pain rating scale (NPR).

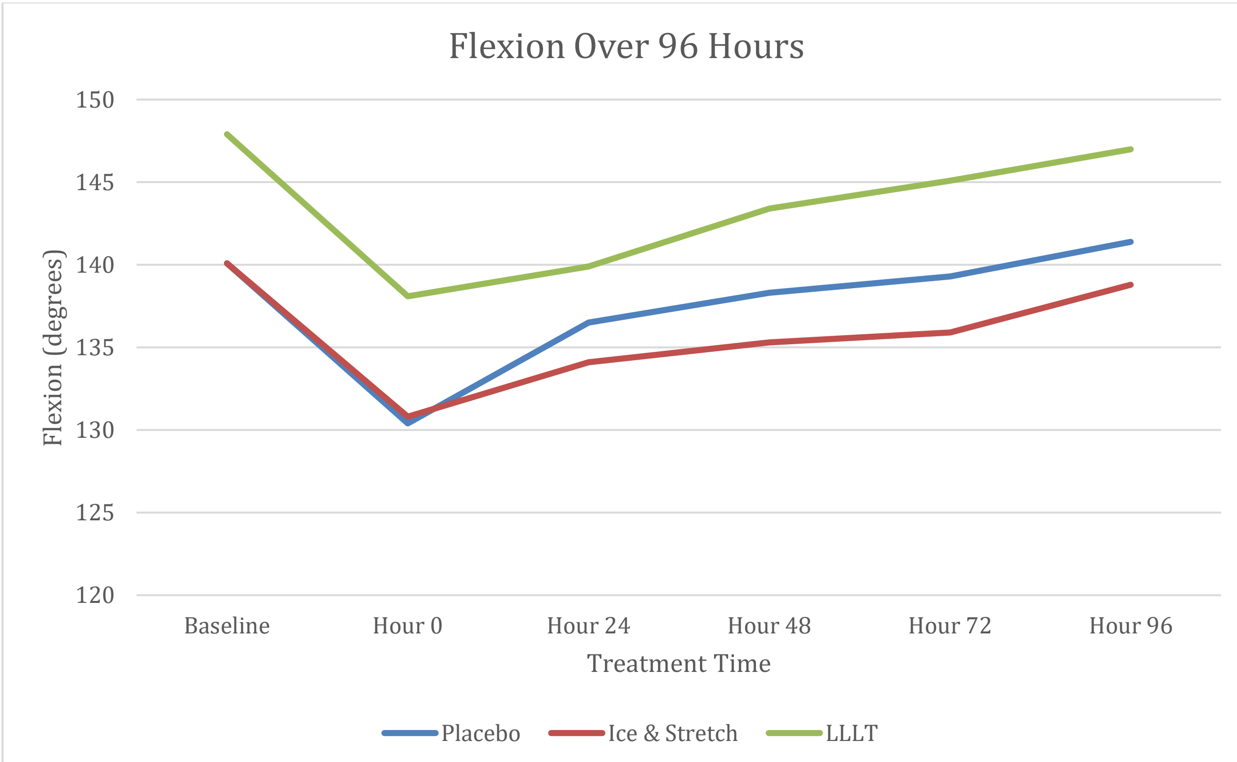

Figure 3: Daily changes in flexion measurements at the elbow associated with DOMS following the eccentric bicep curl exercise as determine using a universal goniometer.

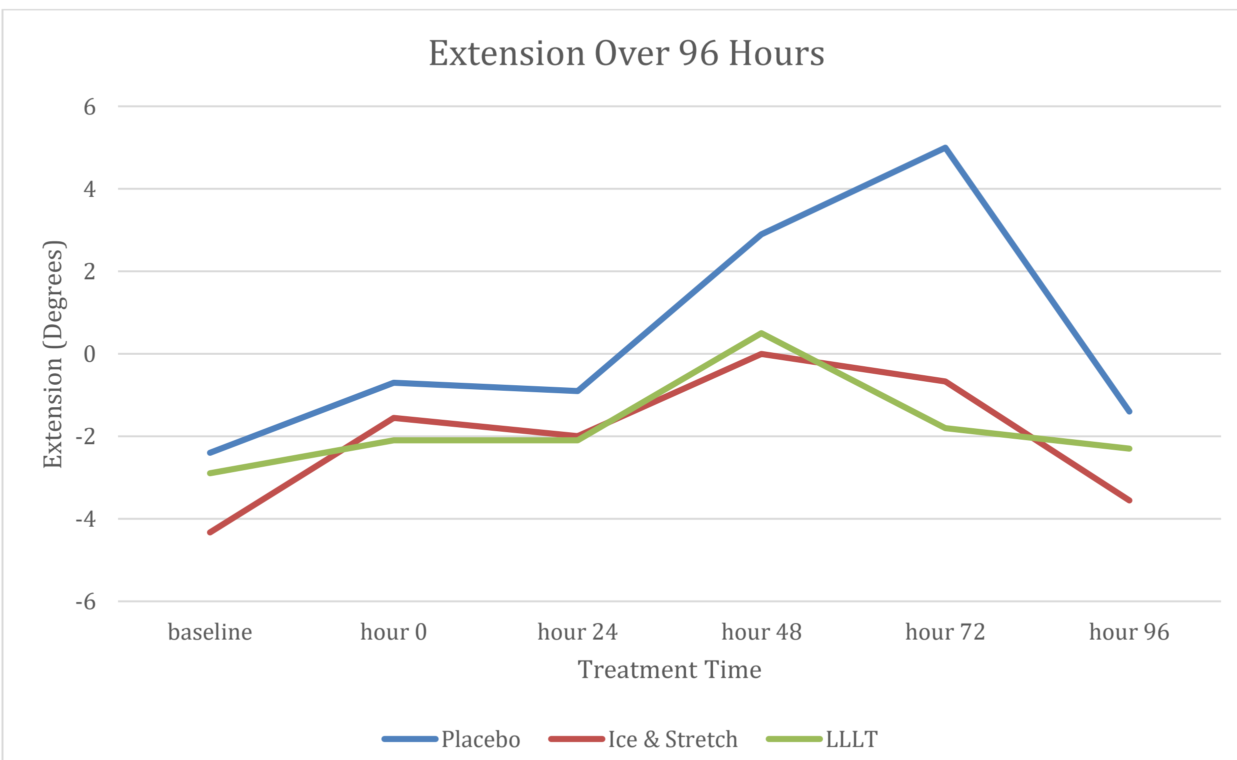

Figure 4: Daily changes in extension measurements at the elbow associated with DOMS following the eccentric bicep curl exercise as determine using a universal goniometer.

Discussion

The purpose of this study was to investigate the effectiveness of LLLT as a treatment method for DOMS and compare it to a traditional treatment of cold whirlpool and stretching. This study confirmed that bicep curls with eccentric contractions can indeed induce DOMS. DOMS also caused obvious effects on perceived pain, flexion, and extension measures.

When considering perceived pain, those in the placebo group showed the greatest spike in pain and their pain levels remained higher than those for the other groups at every time interval. Cold whirlpool and stretch gave patients the most relief due to the numbing effects of ice. Pain scores for the cold whirlpool and stretch group remained lower than the other groups for nearly all time intervals. LLLT treatment was not felt by the subjects during application and immediate results were not reported as they were with cold whirlpool. However, the overall pain level remained lower than the placebo group, suggesting LLLT did have positive effects on pain modulation.

ROM measures of flexion significantly dropped immediately following the induction of DOMS, suggesting that the protocol successfully fatigued the bicep. At that point, there were slight increases in pain but levels were still low on the scale of zero to ten, suggesting the initial resistance to flexion was in fact fatigue. Between hour 0 (directly after DOMS induction) and hour 24, flexion scores began increasing back towards baseline levels again. They continued to rise for all groups except for an additional drop in flexion at hour 72 for the ice and stretching group. The decrease in flexion at this point was minimal and could be hypothesized to be due to the gravity dependent position of the arm in the whirlpool tub. Hanging the arm could have encouraged edema to move from the bicep in the elbow joint space, creating a physical barrier to flexion.

Extension measures remained low, barely rising above hyperextension, in both the LLLT and cold whirlpool groups. Extension in the placebo group was raised significantly, reaching averages of around 6 degrees of flexion. Many patients reported holding their arms in a position as if it were in a sling and tried to avoid using it throughout the day. This kept the muscle in a continually shortened position, which made it difficult to regain extension. The cold whirlpool and stretch group remained at or under zero degrees the entire 96 hours and subjectively reported the least struggle when attempting to extend the arm for daily measurements. This is most likely due to the fact that stretching was incorporated into their treatment, forcing them to move the arm out of a flexed position. The other groups could stay in partially flexed positions for their treatment and were not permitted to stretch at all, so when the time came for measurements it was much more difficult and painful for them to extend. However, the LLLT group did show greater extension than the placebo group, suggesting that LLLT could have had some type of cellular response that caused less of a contraction in the muscle.

Despite the observable and subjectively reported differences between group outcomes, the actual analysis of data showed no statistical significance. Therefore, the results of this study did not provide support for the use of cold whirlpool and stretching or LLLT in the treatment of DOMS. At this point, based on the results found, no suggestions can be made about which treatment is superior to the others for reducing the signs and symptoms of DOMS.

Conclusion

If this study were to be completed again, a few changes would have been advisable. The addition of other daily measures to track DOMS and recovery would have also been valuable. Circumference measures around the bicep and elbow would have helped track the development and migration of swelling in the affected arm. Range of motion measurements should have been taking 3 times each for flexion and extension, and the average should have been recorded to lessen the room for error. If the equipment was available, it also would have been helpful to take blood and/or urine tests to track markers of muscle damage and inflammation. This would have allowed some insight into the effectiveness of the treatments at a cellular level.

Biodex measures to assess strength have been determined to be very important in the recovery from DOMS and should have been completed in this study. Unfortunately, daily biodex measures on every participant were not realistically possible due to time and training constraints. It has been shown that pain is not an accurate marker of recovery from strength loss associated with DOMS. Pain usually disappears within a week, however, isometric strength loss can take over two weeks to return.[4] A larger number of participants would make results more reliable and progress should have been tracked for 7 days rather than 5. Much of our data was not significant because patients did not fully return to baseline measures. If the study were to be extended to 7 days, the participants would have an additional 48 for recovery and more would be likely to return to baseline measures or better.

The attempts to find the superior treatment did not provide obvious answers. There still remains to be no gold standard treatment for DOMS and often times the best treatment will not be just one modality, but a combination of different strategies. The use of a familiar treatment may have the best influence on recovery. The psychological benefit may end up being more important than the physiological benefit and more research should be done on the psychological influence on recovery.[7] The treatment protocol for LLLT is still unclear and the biophysical effects are unknown. Research needs to be done to determine the adequate dosage, intensity, wavelength, duration, and frequency for the treatment of DOMS and other conditions.[10]

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