Cryotherapy and Laser Therapy Do Not Interfere in the Response to Eccentric Exercise-Induced Muscle Damage: A Randomized Clinical Trial

Liane Macedo, Daniel Borges, Caio Lins, Jamilson Brasileiro

Neuromuscular Performance Analysis Laboratory, Department of Physiotherapy, Federal University of Rio Grande do Norte, Natal, Brazil

ABSTRACT

Macedo LB, Borges DT, Lins CAA, Brasileiro JS. Cryotherapy and Laser Therapy Do Not Interfere in the Response to Eccentric Exercise-Induced Muscle Damage: A Randomized Clinical Trial. JEPonline 2015;18(5):59-68. The purpose of this study was to evaluate the effect of cryotherapy and laser therapy in response to eccentric exercise-induced muscle damage on the biceps brachii muscle. This is a randomized clinical trial with random allocation, composed of 60 active women. All subjects underwent an eccentric exercise protocol (2x10 maximum eccentric contractions of non-dominant elbow flexors at 60°·sec⁻¹) and three assessments (pre, post, and 48 hrs after the intervention) of pain sensation (measured by algometry), peak torque normalized for body weight and power (measured by isokinetic dynamometry), and muscle activation (measured by surface electromyography). No intergroup statistical differences were observed for algometry (P=0.15), peak torque normalized for body weight (P=0.77), power (P=0.70), and RMS (P=0.76). Thus, the findings indicate that cryotherapy and low-level laser therapy are not sufficient to stimulate and treat the eccentric exercise-induced muscle damage.

Key Words: Exercise, Muscle, Isokinetics, Injury
INTRODUCTION

Exercise-induced muscle damage affects primarily individuals who resumed strenuous exercise involving eccentric contractions (13,20,26) after a period of non-activity. Eccentric exercise-induced mechanical stress leads to overstretched of sarcomeres, triggering a series of events, such as microlesions in the connective tissue, misalignment of sarcomere bands and rupture of Z lines (18,24). This break in functional unity promotes an inflammatory process that results in the sensation of pain and discomfort (1).

Delayed onset muscle soreness (DOMS) is characterized as a painful sensation during contraction, stretching, and/or pressure placed on the exercised muscle (27,28). Symptoms appear in the first 24 hrs after the conclusion of the activity, the peak occurring between 24 and 72 hrs, and dissipating between 5 and 7 days (27,29). In addition to the pain, the structural lesion provoked by exercise and the inflammatory response may result in damage to muscle function and decreased performance (5,16). In order to avoid or reduce these alterations, numerous interventions have been investigated and can be grouped into three categories: (a) pharmacological treatments with non-steroid anti-inflammatory drugs; (b) interventions using nutritional supplements; and (c) physical therapy by means of physical modalities such as the use of ice, ultrasound, laser therapy, electrical stimulation, massage, stretching, warm up, light exercise, immobilization, and rest (7,14,20).

Cryotherapy has been used in sports to help recover from exercise-induced muscle damage (EIMD) that often results from strenuous training and/or competition (3,22). Its effects on damaged tissue help to relieve pain and lowers the inflammatory response and edema, since it provokes local vasoconstriction that reduces capillary, lymphatic, and cell permeability, (2,3,9,24). It has been observed that cooling decreases secondary hypoxia with a consequent decline in muscle necrosis. Furthermore, deceleration of cell metabolism and nerve conduction velocity occurs that limits injury secondary to lesion and pain (2,9). Thus, it is suggested that due to the positive effects caused by cooling, athletes are able to continue training with no decrease in performance during the days following the injury (24).

Another resource that has attracted attention for reducing pain and inducing tissue repair is laser therapy. Low-level laser therapy (LLLT) uses low-power lasers to exert a regulatory action on the inflammatory response, which appears to reduce pain symptoms and stimulates tissue repair (17). Moreover, it is suggested that its effects on biological tissue may reduce DOMS and prevent muscle damage. This is because LLLT may promote a biostimulating effect that increases ATP and collagen synthesis, stimulates angiogenesis and fibroblast proliferation, inhibits pain and oxidative stress, and modulates inflammatory reactions (5,11,12). Thus, the purpose of the present study is to determine if the cryotherapy and laser therapy alter the response to eccentric exercise-induced muscle damage.

METHODS

Subjects
This was a non-probability sample composed of 60 women (22.6 ± 2.5 yrs). Study power was calculated prospectively, obtaining a type 1 error of 0.05 and type 2 of 0.20. It was estimated that 20 subjects would be needed in each group to detect a difference around 10% with power of 80%. The subjects’ torque values for the elbow flexors were statistically compared before, immediately after, and 48 hrs after the interventions.
The inclusion criteria were: female sex, aged between 18 and 28 yrs, healthy, considered active according to the International Physical Activity Questionnaire – Short Form (IPAQ), engaged in physical activity involving upper limbs at least 2 times·wk$^{-1}$, exhibited shoulder joint, elbow, and non-dominant hand integrity, no history of osteo-myoarticular injuries in the assessed limb during the 6-month period prior to the study, or neurological, visual and/or non-corrected auditory impairments. Also, they could not be allergic to ice or any absolute contraindication to the use of laser (cancer and pregnancy). Exclusion criteria were: not understanding the commands given in the protocols and/or inadequate performance during assessments.

**Procedures**

This study was a randomized clinical trial that conducted at the Laboratory of Neuromuscular Performance Analysis (LAPERN) at the Department of Physiotherapy of Federal University of Rio Grande do Norte (UFRN). The subjects were recruited by non-probability, convenience sampling, and randomly distributed (using the website, www.randomization.com) into three groups: (a) the control group; (b) the cryotherapy group; and (c) the laser therapy group. All groups underwent three assessments: pre, immediately after, and 48 hrs after intervention.

This study was approved by the local Research Ethics Committee under protocol number 387.826. The present study complied with ethical aspects based on Resolution 466/12 of the National Health Council and Declaration of Helsinki. All the subjects volunteered to take part in the study. Each subject gave informed consent after being advised of the objectives, risks, and benefits of the research. All subjects underwent three assessments (pre, post, and 48 hrs) that consisted of algometry, dynamometry, and electromyography.

A digital pressure algometer (Wagner Force TenTM FDX50, USA) was used to assess pain, measured in Newton (N). The accuracy of the device is ± 0.3% of full scale. Calibration was certified by the manufacturer before the test procedures (serial number 10441). Each subject was positioned in the dynamometer chair with arm supported, relaxed, and elbow extended. The algometer was placed one-third the distance between the cubital fossa and medial acromion of the non-dominant limb, and the assessor applied progressive perpendicular force at a rate of 10 N·sec$^{-1}$ (23). All the subjects were instructed to inform the assessor at the onset of pain, thereby registering pain threshold. Then, the subjects’ skin was prepared with trichotomy and cleaned with 70% alcohol before fixing the electrodes to assess the electromyography. Electrodes were positioned according to SENIAM guidelines (10).

An isokinetic dynamometer (Biodex Multi-Joint System 3®, Biodex Biomedical System Inc, New York, USA) calibrated monthly, according to manufacturer’s recommendations, was used to assess the peak torque normalized for body weight (%) and power (Watts). The subjects were secured with belts in the isokinetic dynamometer chair for dynamometric assessment of the elbow. The rotation axis of the dynamometer was aligned with the lateral epicondyle of the humerus and the lever arm was adjusted to the distal part of the upper limb assessed, maintaining the forearm in the supine position. The range of motion performed during the tests was 90°, initiating with the dynamometer arm in the horizontal position and ending in the vertical position. Adjustments for gravity were carried out at 30° flexion of the dynamometer lever and calculated using equipment software.
Electromyographic assessment was conducted simultaneously with dynamometric evaluation and Root Mean Square (RMS) was analyzed. The electromyographic signal was captured by a four-channel signal conditioner module (EMG System do Brazil®) with a 12-bits analogical-digital (A/D) converter (CAD, 12/36-60K). The device has a common-mode rejection ratio (CMRR) >80 dB, with sampling frequency configured at 2000 Hz and the signal was filtered between 20 and 500 Hz. Signals were amplified 1000 times, 20 times in the electrodes and 50 times in the converter. The electromyography was linked by a battery and connected to a laptop, which received the signal and stored it in a file. EMGLab software (EMG System do Brazil®) was used for digital analysis of the signals.

To normalize the electromyographic signal, the subjects were asked to perform two maximum voluntary isometric contractions (MVIC) at 90° elbow flexion for 5 sec with a 1-min interval between each repetition. Of the two contractions, the electromyographic signal that exhibited the greatest isometric torque was used for normalization (8). Then, the subjects executed two eccentric contractions at 60°·sec⁻¹ to familiarize themselves with the test. After a 2-min rest, 5 maximum eccentric contractions of the elbow flexors were performed at an angular velocity of 60°·sec⁻¹ to assess muscle performance. The electromyographic signal with the greatest torque among the 5 recorded by the dynamometric graph was used to analyze RMS (%). During assessments, a standard verbal command and a visual feedback through the monitor of the isokinetic dynamometer were used to encourage the subjects.

After the initial assessment, the subjects were submitted to an eccentric exercise protocol on an isokinetic dynamometer (2 series of 10 maximum eccentric contractions of non-dominant elbow flexors at 60°·sec⁻¹). A 2-min rest period was allowed between each series and the ROM performed was 90° of flexion at 0° extension of the dynamometer lever.

The subjects in the control group did not undergo any intervention. They remained at rest for 25 min. The cryotherapy group remained seated on the isokinetic dynamometer and a 1 kg ice pack was strapped over the entire biceps brachii muscle and adjacent muscles of the arm under study using a bandage. The application lasted 25 min. A digital thermometer (Salvterm® 1200K, Brazil) with interface was used to measure cutaneous temperature and to ensure the cooling level (4). The interface of the thermometer was isolated from the ice pack to ensure that the temperature was recorded specifically on the skin surface.

A laser device (DMC®, Photon Laser III, Brazil) was used by the laser therapy group. This group received laser application to the muscle belly of the non-dominant biceps brachii muscle at four different points. These points were determined based on the distance between the cubital fossa and the acromion, corresponding to 20%, 30%, 40%, and 50% of the length of the arm, thereby excluding the tendinous region (15). Low-level laser therapy was used with the following parameters: wavelength of 808 nm, power of 100 mW, irradiance of 35.7 W/cm², total energy of 20 J, 4 points (5 J per point) and application time of 49 sec at each point.

The laser probe was applied perpendicularly to the skin. The subjects and the researcher used eye protection against laser irradiation. After application, the individual remained at rest for 25 min to ensure that reassessment was conducted after the same time period in each group. After the interventions each subject underwent two assessments: Immediately (post) and 48 hrs after the interventions, identical to the first assessment.
Statistical Analyses
The sample size of this study was determined by a priori analysis of power, demonstrating the need for at least 20 subjects per group. SPSS for Windows (version 20.0) was used for all statistical analyses. One-way ANOVA was used to investigate baseline differences between groups. A mixed design ANOVA (3x3) was used to investigate changes in algometry, peak torque normalised for body weight, power, and RMS with one between-subjects variable, group, with three levels (control, cryotherapy, and laser therapy), and one within-subject variable, time, with three levels (pre intervention, post intervention, and 48 hrs after intervention). The effect of group, time, and group by time interactions were tested. When the assumption of sphericity was violated, significance was adjusted using the Greenhouse-Geisser method. When the effect of test was significant, the analysis using the multiple comparison Bonferroni post hoc test was applied. A 5% significance level was used (P<0.05).

RESULTS
No initial differences in anthropometric measures or variables analysed were observed between the groups (Table 1).

Table 1. Baseline Characteristics of the Subjects.

<table>
<thead>
<tr>
<th>Variables/Groups</th>
<th>Control Group (n = 20)</th>
<th>Cryotherapy Group (n = 20)</th>
<th>Laser Therapy Group (n = 20)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>22.6 ± 2.1</td>
<td>23.0 ± 2.4</td>
<td>22.3 ± 30</td>
<td>0.67</td>
</tr>
<tr>
<td>BMI (Kg·m⁻²)</td>
<td>22.2 ± 2.4</td>
<td>22.5 ± 2.9</td>
<td>22.2 ± 20</td>
<td>0.95</td>
</tr>
<tr>
<td>Algometry (N)</td>
<td>28.8 ± 11.3</td>
<td>32.2 ± 15.9</td>
<td>33.8 ± 4.4</td>
<td>0.51</td>
</tr>
<tr>
<td>PT/BW (%)</td>
<td>52.5 ± 7.2</td>
<td>49.6 ± 7.6</td>
<td>55.7 ± 11.1</td>
<td>0.10</td>
</tr>
<tr>
<td>Power (Watts)</td>
<td>18.5 ± 4.8</td>
<td>17.4 ± 2.8</td>
<td>20.8 ± 5.8</td>
<td>0.06</td>
</tr>
<tr>
<td>RMS (%)</td>
<td>106.5 ± 26.3</td>
<td>97.2 ± 21.7</td>
<td>94.5 ± 23.3</td>
<td>0.25</td>
</tr>
</tbody>
</table>

*BMI*: body mass index; *PT/BW*: peak torque normalised by body weight; *RMS*: root mean square

In relation to algometry, a significant difference was observed in the laser therapy group between the three times of intervention (pre, post, and 48 hrs). For the control and cryotherapy groups, we found similar responses with a statistical difference at 48 hrs compared to pre and immediate post. However, no intergroup difference was observed (P=0.15) (Figure 1).
Analysis of dynamometric variables showed that peak torque normalized for body weight had altered values in the three groups analyzed, demonstrating a difference between pre and immediate post and 48 hrs. With respect to power, there was a significant difference between pre and immediate post and 48 hrs, in addition to a significant difference between immediate post and 48 hrs for all the groups. The two variables showed no intergroup differences (P=0.77 and P=0.70, respectively) (Figure 1).

Analysis of normalized electromyographic amplitude revealed no significant pre, immediate post, and 48 hrs difference after intervention in the three groups assessed for RMS or any intergroup variation (P=0.76) (Figure 1).

![Figure 1. Means and Standard Deviation of Algometry, Root Mean Square (RMS), Peak Torque Normalized by Body Weight (PT/BW), Power and Comparison Between and Within-Group. *P<0.05 **P<0.01](image)

**DISCUSSION**

The results of the present study show that the use of cryotherapy and laser therapy, as employed in this protocol, does not alter the response to muscle damage for any of the variables analyzed.

The literature has documented that exercise-induced muscle injury causes DOMS (19,26). Pressure algometry is used to assess the threshold and limit of this pain, since it is
characterized as a painful sensation during contraction, stretching, and when pressure is placed on the exercised muscle (27,28). According to the findings of this study, algometric values reached their lowest values after 48 hrs, demonstrating that peak pressure-induced pain occurred two days after exercise, irrespective of the application of cryotherapy or laser therapy. This peak pain may be related to a structural lesion provoked by eccentric exercise, which develops into a series of inflammatory reactions. During this process there is a release of inflammatory mediators that sensitize peripheral nociceptors, thus reducing the threshold of mechanic stimulation (28).

To date, no literatures studies have been found that used a pressure algometer to assess DOMS in subjects that used cryotherapy or laser therapy. We observed only assessment of muscle sensitivity using palpation associated to Visual Analogue Scale (VAS) (24). Although peak pain occurs 48 hrs after activity, dynamometric variables show that the reduction in muscle strength begins in the first 24 hrs in response to the cell lesion provoked by eccentric actions (6,16). This damage would be responsible for the rupture of the sarcolemma and t tubules and the consequent failure of action potential conduction and excitation-contraction coupling, which are the mechanisms responsible for the loss of muscle strength (21,25).

Furthermore, a difference was also observed between normalized peak torque and power. Although the two variables decreased in the first 24 hrs, normalized peak torque remained stable in the following 48 hrs, while power declined even more two days after intervention. We hypothesize that power would be more sensitive in the assessment of muscle injury than peak torque, given that alterations in any part of the dynamometric curve would alter its values. Thus, although eccentric exercise caused muscle damage with the presence of pain and a reduction in performance, there were no alterations in the electromyographic variable (i.e., no differences in normalized RMS value between assessments or between groups).

The literature contains varied results in relation to electromyography after eccentric exercise. Some studies demonstrate an increase in these variables while others show a decline (21,25). Our findings, however, show no alterations, leading us to conclude that surface electromyography is not sensitive enough to reveal alterations in injured muscle fibers (which is likely due to their greater depth). It is also reasonable that the eccentric exercise damages the non-contractile structures of the muscle that are not be detected by surface EMG.

CONCLUSIONS

Based on these findings, we conclude that cryotherapy and low-level laser therapy are not sufficient to stimulate and treat the eccentric exercise-induced muscle damage. We underscore that the results of the present study are limited to healthy, young and active women who underwent eccentric exercise-induced muscle damage. In addition, we suggest that future studies should include a longer period of intervention and a greater number of revaluations.
ACKNOWLEDGMENTS

We thank all the volunteers that participated in this study, the CNPq and CAPES (National Research Council) for financial support.

Address for correspondence: Jamilson S. Brasileiro, PhD, Universidade Federal do Rio Grande do Norte, Departamento de Fisioterapia, Av. Senador Salgado Filho, 3000, Campos Universitário, Lagoa Nova, Natal/RN, Brasil, CEP: 59078-970. Email:brasileiro@ufrnet.br

REFERENCES


**Disclaimer**

The opinions expressed in *JEPonline* are those of the authors and are not attributable to *JEPonline*, the editorial staff or the ASEP organization.