The Effectiveness of Cryotherapy in the Treatment of Exercise-Induced Muscle Soreness

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ABSTRACT

Muscle soreness due to unaccustomed physical activity has plagued active individuals for centuries. A person experiencing delayed onset muscle soreness (DOMS) will notice pain and aching within the affected muscles, decreased range of motion and loss in muscle strength beginning 12-24 hours after exercise, peaking between 48 and 72 hours and subsiding within five to seven days post-exercise. The severity is variable, ranging from a mild discomfort to severe debilitating pain that limits the use of muscles. The purpose of this study was to investigate the effectiveness of cryotherapy in the prevention and treatment of DOMS. Twenty-one subjects between the ages of 18-25 were randomly assigned to either the test or control groups. Pre-exercise measures were recorded for maximal voluntary contraction and perceived soreness. Subjects performed eccentric, free-weight curl exercises until fatigue using a 10-lb dumbbell at a tempo of one second for the concentric phase and three seconds for the eccentric phase to induce muscle soreness. The treatment group underwent 30-minute ice treatments, which were administered immediately after exercise, 2, 4, 6, 24, and 48 hours thereafter. Dependent variables were assessed at 0, 24, 48, 72, and 96 hours after exercise. Significant differences occurred in perceived pain with respect to time (ANOVA ($P<0.05$)). There was a significant difference between test and control groups in perceived pain while holding a 10-lb dumbbell with the arm held static at 0^{o} and while performing an elbow flexion movement. No significance difference was noted between groups for the recovery of isometric force production of the biceps at 90^{o} elbow flexion ($P=0.503$). The pattern of data suggests that the use of ice in the treatment of DOMS is effective in minimizing perceived pain 24-96 hours after activity. Cryotherapy was found to be ineffective in reducing the functional deficits associated with DOMS.

Key words: cryotherapy, delayed onset muscle soreness

INTRODUCTION

Every active person at some time has experienced general muscle soreness resulting from unaccustomed physical activity. Exercised-induced muscle soreness can either be classified as acute or delayed onset.[1-4] Acute onset occurs during exercise and may last four to six hours post-exercise before subsiding. Delayed onset muscle soreness (DOMS) typically appears approximately 12 hours after activity and may last for several days following exercise.[1,2] It is perhaps one of the most common and recurrent forms of sports injury.[2] A person experiencing DOMS will notice soreness and aching within the affected muscles beginning 12-24 hours after exercise (and peaking at 48-72 hours), tenderness with palpation throughout the involved muscle belly or at the myotendinous junction, increased muscle tension, decreased range of motion, decreased muscle strength, local edema and warmth, stiffness and resistance to stretching.[1-5] The severity is variable, ranging from a mild discomfort to severe debilitating pain that limits the use of muscles. Since DOMS is known to result in a reduction in contractile function and cause muscle soreness that may last for several days post-exercise, it is likely to have an unfavorable effect on athletic performance.[3] It takes up to three or four days before the symptoms gradually subside.[2]

Despite the considerable evidence of muscle damage produced with repeated eccentric contractions, the cause of delayed onset muscle pain is still currently questioned.[4,6] The cause of DOMS appears to be linked to a form of contraction-induced, microtrauma of muscle fibers and/or connective tissue in and around muscle which results in degeneration of the tissue. This structural damage to muscle and connective tissue results in alterations of muscle function, joint mechanics and produces a less than optimal training intensity; therefore, an individual experiencing DOMS has an increased risk of further injury if premature return to sport is attempted. Reasonable evidence supports the concept that high intensity eccentric muscle contractions stress the muscle enough to elicit severe symptoms of DOMS at a greater frequency and severity than other types of muscle actions.[3-5]

Minimizing the effects of DOMS should be a concern to coaches, athletes, athletic trainers, physical therapists and other medical personnel due to the presence of pain and potential risk for debilitating performance of athletes. Nevertheless, little research exists on the prevention and treatment of DOMS, and treatment strategies are still unclear despite the high incidence in novice and elite athletes.[4] Effective treatment is continually being sought, because currently the efficacy of DOMS treatment strategies have produced mixed results.

Cryotherapy is defined as the therapeutic application of any substance to the body that results in a decrease of tissue temperature.[2,7] The application of cold is a widely used practice in sports medicine and has been proven to provide an analgesic effect along with decreasing tissue blood flow by constricting capillaries, reducing capillary permeability, decreasing tissue metabolism and oxygen utilization. When applied intermittently after injury, cryotherapy is effective in reducing the inflammatory response and the formation of edema.[2,4,7] Research has shown that cryotherapy after vigorous eccentric exercise reduces signs of muscle damage, but has not been proven to have an effect on the perpetuation of muscle tenderness or strength deficit caused by DOMS.[1,3,4] In a study completed by Isabell, et al. which investigated the effects of a repeated 15-minute ice massage treatments, ice massage with exercise, and exercise on the prevention and treatment of DOMS, the results did not show evidence that cryotherapy is an effective treatment technique for the prevention and/or treatment of DOMS.[1] However, the extent to which tissue is cooled depends on the cold medium in addition to the length of cold exposure; therefore, the longer the cold exposure, the deeper the cooling of the tissue. With deeper cooling of the tissue, the effects of cryotherapy to reduce many of the adverse conditions related to the inflammatory phase of an acute injury will be accentuated.[2]

Although some interventions for the management of DOMS appear to have potential, a definitive treatment strategy has yet to be determined. Currently, the literature is unclear with regards to the efficacy of cryotherapy as a treatment option. Variability and inconsistencies in the methods and applications within research studies made it necessary to continue to pursue the effectiveness of cryotherapy after high intensity eccentric exercise. The purpose of this study was to investigate the effects of an ice bag on the prevention and treatment of DOMS.

METHODS

Subjects

Twenty-one physically active subjects between the ages of 18-25 (13 females, 8 males) were required to complete a medical health questionnaire, provide informed consent and agree to refrain from any form of potentially muscle damaging resistance training or exercise before participating in the study. The criterion for subject inclusion was no previous history of upper arm or elbow injury, absence of any current arm pain/discomfort, and ability to demonstrate full, pain-free range of motion about the elbow joint prior to participation in the study. Participants were also asked to refrain from the use of non-steroidal anti-inflammatory drugs and/or alternate treatment strategies throughout the duration of the study. This study consisted of four phases: pre-exercise measurements, induction of DOMS, cryotherapy treatments, and post-exercise measurements. Subjects were randomly assigned to either the treatment or control groups. Ten subjects were assigned to the control group and eleven subjects were assigned to the treatment group.

Pre-Exercise Measurements

Isometric flexion strength and perceived soreness at rest and at work were the dependent variables measured before the induction of muscle soreness. Subjects were situated on the Biodex machine with their elbow at 90^o flexion. Parameters for each participant, including chair height, arm length, chair distance and angle of incline, were recorded and maintained with each trial throughout the duration of the study to ensure consistency. Subjects performed three submaximal contractions on the Biodex machine to familiarize themselves with the machine and demonstrate their understanding of the testing protocol. Subjects then performed three, five-second isometric contractions of the biceps at 90^o elbow flexion. The average of the three scores was recorded as the pre-exercise strength measurement for statistical analysis.

Perceived pain or soreness was determined using a visual analog scale: (0) No Pain, (5) Moderate Pain, (10) Worst Pain. Perceived soreness was measured while holding a 10-lb dumbbell static at 0^o, at 90^o elbow flexion, and while performing a full elbow flexion movement. Perceived soreness was recorded using the perceived soreness scale for each set of contractions.

Induction of Delayed Onset Muscle Soreness

Muscle soreness was induced in the non-dominant arm using concentric and eccentric dumbbell curl exercises. Subjects were instructed to perform elbow flexion/extension of their non-dominant arm using a 10-lb dumbbell while standing, until reaching the point of fatigue (Figure 1). Fatigue was considered the state of physiological inability for a muscle to produce a contraction even though the muscle is receiving stimuli.[8] The eccentric portion of the exercise was emphasized by instructing the subject to complete each curl at a rate of one second for the concentric phase and three seconds for the eccentric phase. At the point that the subjects were unable to perform the concentric contraction within one second, they were allowed to provide assistance to raise the weight with the opposite hand as long as the three second eccentric contraction was maintained unassisted. Consistency of this tempo was upheld with the use of a standard metronome. The total exercise time was no longer than 10 minutes.

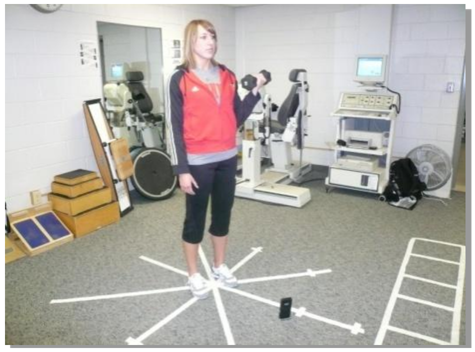

Figure 1. Induction of muscle soreness

Treatment Protocols

The treatment group underwent a 30-minute ice treatment administered immediately after exercise and then 2, 4, 6, 24, and 48 hours thereafter. Subjects of the test group were provided shaved ice in 9-1/2" x 18" 1-mil polyethylene bags, a 6-inch single-length ACE wrap to secure the ice to the bicep for treatment and a treatment log to document the time of day and duration of treatments. Written and verbal instructions were provided to each participant to ensure that correct procedures were being maintained. The control group underwent no treatment immediately after exercise or thereafter.

Post-Exercise Measurements

Post-exercise measurements for strength and perceived muscle soreness were obtained using the same procedures outlined for pre-exercise measurements. The participants completed isometric flexion strength measurements at 90^{o} elbow flexion and perceived muscle soreness to indicate the degree of muscle damage immediately after exercise, 24, 48, 72 and 96 hours later. Post-exercise measurements were obtained preceding treatment when treatment and assessment coincided.

Statistical Analysis

A repeated measures analysis of variance (ANOVA) was used to measure differences between groups. Comparisons between groups at points in time were made using Tukey's post-hoc test ($P<0.05$). Pre-exercise measures recorded for maximal voluntary contraction and perceived pain prior to exercise were used as baseline measurements for the statistical analysis.

RESULTS

A two-way ANOVA with repeated measures revealed a significant difference in the interaction between the treatment and control group and time in regards to perceived pain while holding a 10-lb dumbbell measured at 0° and during elbow flexion at 24, 48, 72, and 96 hours post-exercise ($P<0.05$). Results are shown in Figures 2 and 3. There was no significant difference in the interaction of perceived pain measurements and time at 90° elbow flexion between the test and control groups ($P= 0.554$). See Figure 4 for results.

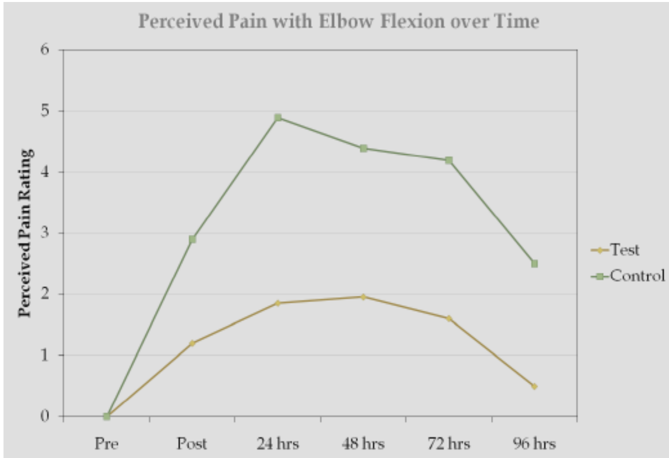

Figure 2. Perceived pain with elbow flexion over time

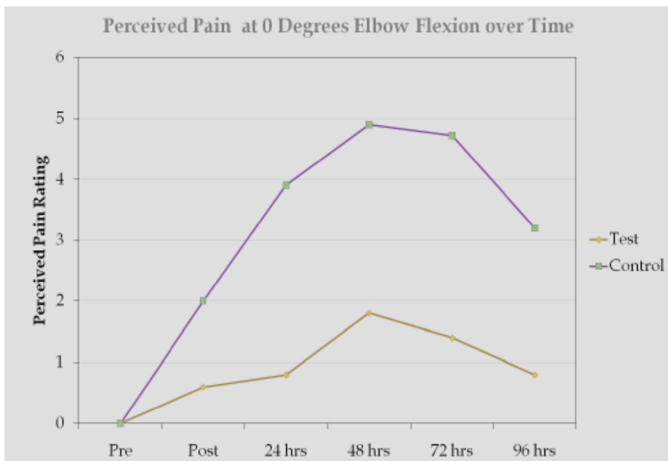

Figure 3. Perceived pain while at 0^{o} elbow flexion over time

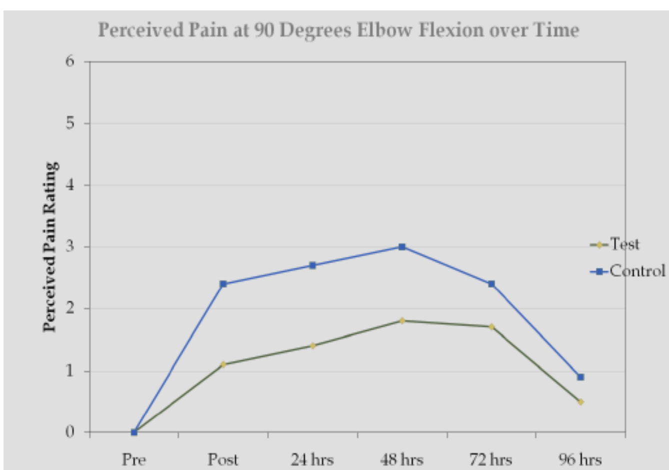

Figure 4. Perceived pain while at 90^{o} elbow flexion over time

The trend in recovery of isometric force production of the biceps at 90° elbow flexion was consistent between both groups. A tendency was observed for the test group to demonstrate stronger measurements of isometric force production throughout the duration of the study; however, there was no significant difference between groups for the recovery of strength deficits associated with DOMS over time (P= 0.503). See Figure 5.

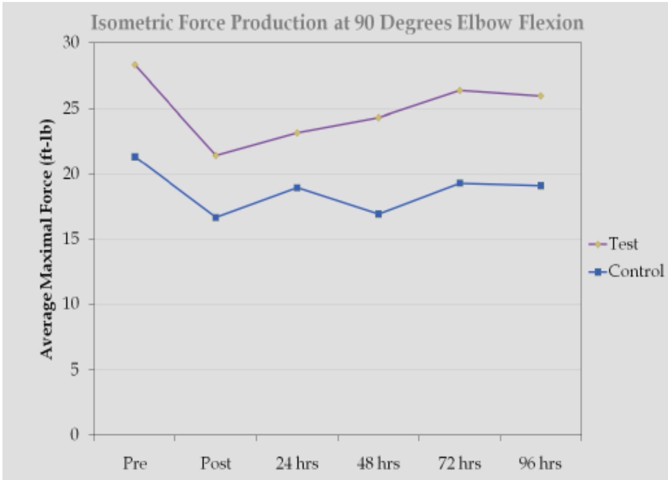

Figure 5. Isometric force production over time

Figures 2-5 exhibit the pattern of change in flexion strength, perception of soreness at 0^o, 90^o, and while performing a full elbow flexion movement with respect to treatment and to time. Peak decreases in isometric force production occurred immediately after exercise for both groups. Soreness values peaked at 48 hours for both treatment and control groups at 0^o and 90^o elbow flexion. Perceived soreness with elbow flexion peaked at 24 hours for the test group and 48 hours for the control group.

DISCUSSION

This study attempted to determine the effectiveness of repeated ice bag treatments in the prevention and treatment of muscular soreness. The results of this study have revealed that cryotherapy is effective in minimizing the perceived pain associated with DOMS. There was a significant improvement in perceived pain in the test group while subjects were holding a 10-lb dumbbell at 0^o elbow flexion and during a biceps curl movement, beginning at 24 hours post-exercise. However, it is interesting to note that there was no significant difference between groups in perceived pain with subjects holding a 10-lb dumbbell at 90^o elbow flexion. This observation was anticipated due to the position of the muscle in a shortened state. A shortened muscle position creates less tension within the muscle fibers; thus, relieving the exacerbation of symptoms associated with DOMS when the muscle is stretched or lengthened. An interesting observation is the considerable perceived pain experienced by subjects while the arms were held static at 0^o and while performing a full, elbow flexion movement. This signifies that the mechanism of pain produced by DOMS is not only isolated to contracting muscles, but also manifests itself within muscles at rest.

Because of the lack of significant evidence, it cannot be said with certainty that ice treatments are or are not effective in expediting the recovery of strength deficits associated with DOMS. Although not statistically significant, the data illustrated in Figure 5 indicates a pattern that warrants further investigation.

Isabell, et al. did not find significant differences in their criterion indicators of DOMS resulting from the use of ice massage.[1] However, we felt that their mode of cryotherapy treatment was less effective than other forms of ice application, and that the treatment time was too short. Our study addressed these weaknesses by changing the mode of ice application to the use of an ice bag for treatment, and by increasing the treatment time from 15 minutes to 30 minutes.

In summary, this study provides additional support that repeated exercise that emphasizes the eccentric phase produces DOMS. Decreases in strength correspond with increases in perceived pain. Although the therapeutic use of ice was effective in minimizing the perceived soreness associated with DOMS, ice bag treatments were not effective in expediting the recovery of isometric force production. Additional research that measures range of motion in addition to torque production through a full range of motion is needed before the effectiveness of cryotherapy in the treatment of DOMS can be concluded.

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