2018

The effects of massage therapy on delayed onset muscle soreness

Carli Mueller
University of Northern Iowa

THE EFFECTS OF MASSAGE THERAPY ON DELAYED ONSET MUSCLE SORENESS

An Abstract of a Thesis

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Science in Athletic Training

Carli Mueller

University of Northern Iowa

July 2018

ABSTRACT

Context: Cupping massage and petrissage may be beneficial in the treatment of DOMS, however, there is limited research on the application and use of cupping massage on DOMS. This study examines the effectiveness of petrissage versus cupping massage on the pain associated with DOMS among a healthy population. Objective: To determine the efficacy of cupping massage in comparison to petrissage on the treatment of pain associated with acute muscle injury. Design: Experimental, single blinded study with stratification of participants. Participants: Thirty-two healthy individuals between the ages of 18 and 22. Methods: Participants underwent a protocol to induce DOMS on the bicep muscle. They were then randomly divided into two treatment groups; petrissage and cupping massage. Participants then received treatment 48 hours post-induction, and every 24 hours subsequently until they reported no pain (zero out of ten) on the numeric rating scale (NRS). Outcome Measures: Perceived pain on an 11-point NRS. Results: The repeated measures ANOVA revealed a significant difference between pain score prior to the DOMS session and the scores reported just prior to the first treatment session (F (1,30) =140.90, $p < 0.001$), but no session by group interaction (1,30) = 0.31, p = 0.58). DOMS was induced and the groups were the same prior to the first treatment. However, there was no difference between the two groups before, during, or immediately after treatment session one through four ($p > 0.05$). Thirty-one participants reported that they felt the treatment they received was effective in relieving DOMS. Conclusion: Based on the results, there is no difference between cupping massage and petrissage in their effect on pain associated with DOMS. Although 97% (31/32) of participants

perceived their treatment as effective, some in the cupping group reported an increase in pain following the first two cupping sessions. Clinically, cupping massage cannot be recommended over petrissage for the treatment of DOMS.

THE EFFECTS OF MASSAGE THERAPY ON DELAYED ONSET MUSCLE SORENESS

A Thesis

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Science in Athletic Training

Carli Mueller

University of Northern Iowa

July 2018

THESIS APPROVAL

This Study by: Carli Mueller

Entitled: The effects of massage therapy on delayed onset muscle soreness

has been approved as meeting the thesis requirement for the

Degree of Master of Science in Athletic Training

___________	____
Date	Dr. Todd Evans, Co-Chair, Thesis Committee
___________	____
Date	Dr. Tricia Schrage, Co-Chair, Thesis Committee
___________	____
Date	Dr. Kelli Snyder, Thesis Committee Member
___________	____
Date	Dr. Patrick Pease, Interim Dean, Graduate College

DEDICATION

I would like to dedicate this thesis to my parents, Chuck and Barb Mueller; sister, Krista Depies; brother, Nick Mueller; and my fiancé, Jake Reuteler. Your love, support, encouraging words, and comfort have helped me to accomplish higher education. You are the reasons I am able to make my dreams come true. Thank you and I love you.

ACKNOWLEDGEMENTS

I would like to express a special thank you to Dr. Todd Evans and Dr. Tricia Schrage, who served as co-chairs of this research thesis. I appreciate all the time, encouragement, guidance, and support throughout this entire journey. A special thank you as well to Dr. Kelli Snyder for her help on my committee. I could not have done this without you.

TABLE OF CONTENTS

PAGE

LIST OF TABLES

CHAPTER I

INTRODUCTION

Delayed onset of muscle soreness (DOMS) is an acute muscle injury caused by the over exertion of a muscle during exercise (Haensel et al., 2012). DOMS often onsets eight to 24 hours post-exercise and can last up to 96 hours (Butterfield et al., 1997; Cheung, Hume, & Maxwell, 2003; Gulick & Kimura, 1996; Isabell, Durrant, Myrer, & Anderson, 1992). Due to a number of theories including an increase of inflammation, connective tissue damage, muscle spasm, and lactic acid build up, DOMS can cause pain, stiffness, and decreased muscle function in areas effected (Haensel et al., 2012; Isabell et al., 1992). This can then effect the way an athlete performs at practice or competition due to compensation (Isabell et al., 1992). Eccentric exercises, often performed during rehabilitation of muscle or tendon injuries, tend to cause increased symptoms of DOMS (Bakhtiary, Safavi-Farokhi, & Aminian-Far, 2007; Kuehl, Perrier, Elliot, & Chesnutt, 2010). This indicates that an athlete may experience soreness while trying to return to full participation. Additionally, the athlete may feel soreness from rehabilitation, thus compounding the effect of the injury. Although DOMS typically resolves within 96 hours (Bakhtiary et al., 2007), the symptoms are felt by many who are physically active and can effect performance.

DOMS can be treated using many therapeutic techniques, including thermal modalities (Fonda & Sarabon, 2013; Frey Law et al., 2008; Hilbert, Sforzo, & Swensen, 2003; Kuligouski, Lephart, Gianantonio, & Blanc, 1998; Mancinelli et al., 2006; Petrofsky et al., 2013; Zainuddin, Newton, Sacco, & Nosaka, 2005) and massage (Ogai, Yamane, Matsumoto, & Kosaka, 2008; Zainuddin et al., 2005). Research suggests that whole body cryotherapy immersion significantly reduced the symptoms of DOMS consistently in comparison to a control group (Fonda & Sarabon, 2013). Additionally, cold therapy and contrast baths were more effective than warm whirlpool baths in reducing pain associated with DOMS when tested on participants who endured DOMS induction and were split into four treatment groups (Kuligouski et al., 1998). However, dry and moist heat packs also significantly decreased the pain caused by DOMS compared to a control group in a study conducted by Petrofsky et al. (2013). In addition to thermotherapies, massage therapies have consistently significantly reduced the symptom of pain that associated with DOMS (Frey Law et al., 2008; Hilbert et al., 2003; Mancinelli et al., 2006; Zainuddin et al., 2005). Massage techniques including petrissage and effleurage provided significant relief from DOMS in painful muscles of the wrist flexors (Frey Law et al., 2008), thigh muscles (Mancinelli et al., 2006), elbow flexors (Zainuddin et al., 2005), and hamstrings (Hilbert, et al., 2003), in comparison to controls.

Other therapeutic interventions have been studied but did not reduce DOMS. Thesis include electrical modalities (Allen, Mattacola, & Perrin, 1999; Butterfield et al., 1997; Fonda & Sarabon, 2013; Haensel et al., 2012; Jakeman, Byrne, Eston, 2010; Kim et al., 2011; Lauche et al., 2013; Mancinelli et al., 2006; Minder et al., 2002; Weber, Servedio, & Woodall, 1994) and nonsteroidal anti-inflammatory drugs (Donnelly, Maughan, & Whiting, 1990; Donnelly, McCormick, Maughan, Whiting, & Clarkson, 1988; Grossman, Arnold, Perrin, & Kahler, 1995). When compared to a placebo, ibuprofen or diclofenac before and after exercise did not have a significant relief in soreness compared to a placebo pill (Donnelly et al., 1990; Donnelly et al., 1988; Grossman et al., 1995). Likewise, electrical modalities including interferential therapy (Minder et al., 2002), high-volt pulsed current (Butterfield et al., 1997), and microcurrent electrical neuromuscular stimulation (Allen et al., 1999) did not reduce the symptoms of DOMS on participants after exercise in comparison to a sham treatment.

Massage, as mentioned previously, is commonly associated with the treatment of DOMS to reduce the pain (Zainuddin et al., 2005). Petrissage is a massage technique that uses kneading or lifting of the skin is thought to increase circulation and lymphatic drainage, as well as relax muscles (Ogai et al., 2008). Petrissage uses a form of negative pressure, or pulling away from the body instead of pushing into the tissues (Ogai et al., 2008). The theory behind this technique is comparable to a treatment called cupping therapy. Cupping therapy uses a vacuum suction in a "cup" to create negative pressure, which potentially will increase blood flow stimulating the lymphatic system by removing toxins from the blood (Chi et al., 2016; Lauche et al., 2011). The vacuum is created by either a hand pump, suction bulb, or a flame, which removes the oxygen from the cup (Markowski et al., 2014). Cups may be left either static on the skin (static or stationary cupping) or may be moved around the skin using a lubricant (cupping massage or sliding cupping) (Hong, 2000, 2001). When left on the skin, the typical treatment time ranges from five (Farhadi et al., 2009; Michalsen et al., 2009; Teut et al., 2012), ten (Akbarzade et al., 2016; Chi et al., 2016; Cramer et al., 2011; Ge, Leson, & Vukovic, 2017; Lauche et al., 2011, 2012, 2016; Markowski et al., 2014; Michalsen et al., 2009; Teut et al., 2012), 15 (Akbarzadeh et al., 2014; Cramer et al., 2011; Lauche et al., 2012, 2013, 2016; Lee, Kim, Kong, Lee, & Shin, 2010), to 20 minutes (Akbarzade et al., 2016; Akbarzadeh et al., 2014; Lauche et al., 2011), depending on the severity of the injury and the changes in the color of the skin during the treatment. Stationary cupping therapy treatments in research have significantly decreased symptoms from chronic neck pain (Chi et al., 2016; Lauche et al., 2011, 2012, 2013), low back pain (AlBedah et al., 2015; Farhadi et al., 2009; Kim et al., 2011; Markowski et al., 2014), knee pain (Ullah, Younis, Wali, 2007), carpal tunnel syndrome (Michalsen et al., 2009), as well as other conditions such as psoriasis (Malik, Akhter, & Kamal, 2015). Sliding, or massage, cupping is the treatment sliding vacuum suction cups along the skin up and down with a lubricant, usually an oil, to promote increased blood flow (Hong, 2001). By utilizing the effects of both massage and cupping, massage cupping is intended to increase the treatment area compared to stationary cupping, increase blood circulation and improve the metabolism of waste and toxins in the blood (Hong, 2001). This treatment can be applied every three to five days and is suggested for treating many aliments such as respiratory disease, lumbar pain, acne, congestion, swelling, and digestive issues (Hong, 2001) as well as skeletal impairments such as cervical spondylosis (Hong, 2000). However, aside from case studies, there is limited science addressing the therapeutic benefits of massage cupping on these specific conditions or acute pain, as experienced with DOMS. Therefore, the impact of massage cupping on acute pain is unknown. The purpose of this study is to investigate the effects of cupping treatment in comparison to petrissage on acute pain associated with DOMS in a healthy population.

Research Questions and Hypothesis

The research questions in this study are:

1. Will cupping massage and petrissage decrease pain after DOMS?

Hypothesis: Cupping massage and petrissage will decrease pain that caused by DOMS.

2. Will petrissage or cupping massage have a greater effect on the symptoms of DOMS?

Hypothesis: Cupping massage will have a greater effect than petrissage on pain associated with DOMS.

Significance of Study

Cupping therapy may have similar results to petrissage on DOMS. If this is the case, athletic trainers, physical therapists, massage therapists, and other health care professionals can utilize cupping therapy to treat DOMS. Cupping therapy could be beneficial in populations such as athletes undergoing rehabilitation or vigorous training, leading to lack of function in the tissues and pain. There is no research to my knowledge that has been conducted on the effects of cupping therapy on DOMS.

Limitations of the Study:

Limitations to this study may include:

1. Blinding was a challenge as cupping left marks on the skin, felt different, and sometimes made a suction noise during application.

2. The recruitment of participants was difficult, as soreness and pain were induced and exercise was not allowed during the study. It was challenging to come up with 32 individuals who were willing to induce DOMS and avoid exercise throughout the study.

3. Pain was the only outcome measured. Other impairments or broader measures of function were not included in these methods.

Definition of Terms

Cupping therapy: a treatment that uses cups to create a vacuum effect to produce negative pressure (AlBedah et al., 2015; Chi et al., 2016; Cramer et al., 2011; Farhadi et al., 2009; Kim et al., 2011; Lauche et al., 2011, 2012, 2013; Malik et al., 2015; Markowski et al., 2014; Michalsen et al., 2009; Teut et al., 2012; Ullah, et al., 2007)

Petrissage: a massage technique in which the tissue is pulled up and away from the underlying tissue (Ogai et al., 2008)

Delayed onset of muscle soreness: pain, discomfort, decreased range of motion and decreased function in a muscle that occurs 24 to 48 hours after exercise (Bakhtiary et al., 2007; Isabell et al., 1992; Mancinelli et al., 2006; Zainuddin et al., 2005)

CHAPTER II

REVIEW OF THE RELATED LITERATURE

Evidence Based Practice & Clinical Outcomes Assessments

Evidence based practice (EBP) is an approach to health care in which clinicians use scientific information and observations to determine what treatment or care to provide to a patient (Evans & Lam, 2011). EBP refers to the literature found to support said treatment plan and focuses on disease-orientated evidence (DOE) and patient-oriented evidence that maters (POEM) (Valovich McLeod et al., 2008). DOE includes physiological measures including blood pressure, bone density, strength, and range of motion (ROM) (Valovich McLeod et al., 2008). POEM is depicted by measurements that is important to the patient such as morbidity and mortality, symptoms such as pain and discomfort, quality of care received, and the cost of health care (Valovich McLeod et al., 2008). One resource clinicians can utilize is data bases to access literature in order to support their clinical findings (Cormack, 2002). Scientific findings are necessary to provide evidence as to why a certain treatment or exercise should be utilized in health care (Cormack, 2002).

Similarly, clinical outcome measures are made up of two parts and are also helpful in determining the appropriate treatment plan for a patient (Valovich McLeod et al., 2008). These clinical outcome measures are essentially the end result of a treatment plan and are further broken down into two parts (Valovich McLeod et al., 2008). Clinician based outcome measures are used to determine the results of a treatment or intervention and include range of motion, strength, girth measurements, and balance scores (Valovich McLeod et al., 2008). The second part is patient based outcomes measures (Valovich McLeod et al., 2008). These outcomes take into consideration what goals the patient may want to achieve and what they would like to get out of the rehabilitation plan (Evans & Lam, 2011; Valovich McLeod et al., 2008). These outcomes can be measured by determining the patients ability to carry out activities of daily living, psychological distress, mental function, social roles, and perceptions of their own health (Clancy & Eisenberg, 1998; Valovich McLeod et al., 2008). Likewise, evaluating a patient's perceived symptoms can be a valued indication of what goals or outcomes must be prioritized in the treatment plan (Clancy & Eisenberg, 1998; Valovich McLeod et al., 2008). One of these perceived symptoms may be pain or discomfort and range of motion (Valovich McLeod et al., 2008). However, this category is unfortunately often over looked in health care (Evans & Lam, 2011).

By implementing and conducting research that assess POEM and patient based outcomes measured, a clinician can determine the most appropriate treatment plan that provides outcomes that actually matter to the patient (Evans & Lam, 2011; Valovich McLeod et al., 2008). Pain is a recurring outcome and symptom that can strongly impact patients' quality of life and daily living (Donabedian, 1988). To improve patient care, research utilizing the patient's subjective measures as outcomes, such as a pain scale (Bijur, Latimer, & Gallagher, 2003), can be conducted to establish quality treatments that can reduce pain and subsequently improve patients' quality of life.

Pain & Delayed Onset Muscle Soreness

Pain is an uncomfortable feeling that is processed by the cerebrum and can occur in the cutaneous layer (skin) or intramuscularly (Svensson, Minoshima, Beydoun, Morrow, & Casey, 1997). There are two broad categories of pain; acute pain and chronic pain. Chronic pain is defined as lasting longer than four and a half months (Price, McGrath, Rafii, & Buckingham, 1983), whereas acute pain is defined as "pain of recent onset or exacerbation of existing pain of sufficient severity" (Bijur, Silver, & Gallagher, 2001, pg 1154). This pain can be brought on by various traumas including injury, wounds, and exercise (Kuehl et al., 2010). Pain can be rated subjectively on different scales. The most common are the visual analog scale (VAS) (Bijur, Silver, & Gallagher, 2001, Bijur et al., 2003, Price et al., 1983) and the numeric rating scale (NRS). (Bijur et al., 2003). Both scales are self-reported by the patient. The VAS is a ten-point rating scale ranging from "no pain= 0" to "worst pain possible= 10" and the patient points to where they feel they appropriately fall on the grid. The VAS is a highly reliable instrument for measuring acute and chronic pain, but can be difficult to administer if the patient does not have the visual acuity, motor function, or cognitive ability to participate (Bijur et al., 2003). The NRS can be adminisered verbally or written and contains a scale of zero to ten, (zero being no pain, ten being the worst pain possible) (Bijur et al., 2003). The patient then marks or verbally tells the clinician what level of pain they are at. This can be a substitute for the VAS if the patient is unable to complete the VAS. The VAS and NRS have similar accuracy when used in the emergency department on acute pain (Bijur et al., 2003).

Acute pain from exercise can arise from a wide variety of activities including endurance and eccentric muscular exercise (Kuehl et al., 2010). This acute pain caused by exercise is commonly referred to as delayed onset muscle soreness, or DOMS. DOMS is a form of muscle injury classified as type 1B (Haensel et al., 2012). It manifests symptoms such as inflammatory pain and pain at rest (Haensel et al., 2012). Patients suffering from DOMS experience limitation in range of motion, swelling, stiffness in muscles that are relieved with stretching (Haensel et al., 2012). Isometric contractions will also be painful with DOMS, and it will affect the entire muscle or muscle group (Haensel et al., 2012). DOMS generally will onset eight to 24 hours post-exercise, is most painful at 24 to 72 hours post, and can last up to 96 hours (Butterfield et al., 1997; Cheung et al., 2003; Gulick & Kimura, 1996; Isabell et al., 1992). There are many theories as to what actually causes the pain in DOM including but not limited to lactic acid build up, muscle spasm, actual connective tissue damage, inflammation, and muscle damage (Cheung et al., 2003). It is possible these theories may all be associated with the pain caused by DOMS, however, the inflammatory response to muscle damage is most supported in the literature (Cheung et al., 2003). This inflammatory response is triggered by trauma to the muscles which cause a break down of collagen, resulting in pain, decreased ROM and strength (Isabell et al., 1992). Eccentric muscle exercises such as running down hill and eccentric weight lifting can cause oxidative tissue damage, which triggers the inflammatory process (Kuehl et al., 2010). Free radicals are eventually released, which inhibit the pain (Kuehl et al., 2010).

Pain associated with DOMS is temporary, and many treatments to reduce symptoms have been studied. Ice (Fonda & Sarabon, 2013; Isabell et al., 1992; Kuligouski et al., 1998), exercise (Isabell et al., 1992), massage(Isabell et al., 1992), nonsteroidal anti-inflammatory drugs (NSAIDS) (Gulick & Kimura, 1996), stretching, and movement or light exercise (Isabell et al., 1992) as well as electrical modalities(Allen et al., 1999; Butterfield et al., 1997; Kim et al., 2011; Minder et al., 2002; Weber et al., 1994) are just some of the potential treatments that have been researched.

The effect of whole-body cryotherapy on pain caused by DOMS affecting the hamstrings was examined on a control and experimental group and provided evidence regarding cold therapy on DOMS soreness (Fonda & Sarabon, 2013). Eleven young male adults who are healthy and regularly participating in moderate physical activity performed damaging exercises to induce DOMS of the hamstrings on two separate occasions, ten weeks apart. The participants were randomly split into control and experimental groups. The study was performed once and after a ten-week period, the DOMS inducing protocol was performed again and the participants switched groups. Perceived pain was one of the variables measured using a ten-centimeter VAS from zero to ten (0= no pain, 10= severe pain). Measures were taken at baseline the day before the protocol, and at one, 24, 48, 72, 96, and 120 hours post-exercise. The protocol to induce DOMS consisted of a 15-minute warm up, five sets of ten drop jumps, five sets of ten bilateral leg girls at 75% of one repetition maximum (1RM), and ten repetitions of eccentric leg curls at 130% of 1RM. Each series of exercises was separated by one-minute rest. The experimental group were treated in a three minutes whole body cryotherapy bath in a cryo-cabin every day for five days following the exercises where there control group received no treatment with the hands and head out of the water and warm shoes on the feet (Fonda & Sarabon, 2013). There were statistically significant findings between the two groups for pain sensation at the one to 72 hours post-exercises marks. Pain was consistently lower during in the whole body cryotherapy group in comparison to the control group with a peak in differences at the 48 hours assessment (Fonda & Sarabon, 2013). Similarly, Kuligowski et al. (1998) found that a cold whirlpool and contrast therapy were more effective than warm whirlpool therapy in reducing the pain associated DOMS. Fifty-six healthy male and female subjects who have not participated in upper extremity weight training program for nine weeks performed eccentric contractions of the elbow flexors in order to induce soreness. The protocol consisted of eccentric elbow extensions with resistance of their IRM plus 2.27 kilograms until failure or until they reached ten repetitions followed by one-minute rest. If failure was reached, the weight decreased by 2.27 kilograms and the set was completed. A total of five sets were completed until the participant reached 50 repetitions total. Participants were randomly divided into four treatments groups. The control group received no treatment. The warm whirlpool group and the cold whirlpool group submerged their arm up to the mid-deltoid level for 24 minutes.

The contrast therapy group submerged their arm into a warm whirlpool and cold whirlpool at a three to one-minute ratio for 24 minutes. Treatment was administered immediately after exercise, at 24, 48, and 72 hours (Kuligouski et al., 1998). Subjects rated their pain on a Graphic Pain Rating Scale as dull ache, slight pain, more slight pain, painful, very painful, or unbearable pain after each treatment. Statistical significances were noted between the cold whirlpool and warm whirlpool groups, the contrast therapy and warm whirlpool groups, the cold whirlpool and control groups, and the contrast therapy and control groups. However, there were no significant differences between the warm whirlpool and control groups or the cold whirlpool and contrast therapy groups. Researchers concluded that the cold whirlpool and contrast baths returned the participants' pain levels to baseline (Kuligouski et al., 1998). Additionally, the warm whirlpool was more effective in reducing perceived soreness than no treatment at all, however the difference was not as significant as the other treatments in reducing DOMS pain (Kuligouski et al., 1998).

In addition to cold, heat can also be used to relieve the symptoms of DOMS pain and can be applied using a moist heat pack or a dry heat pack (Petrofsky et al., 2013). Moist heat has been clinically shown to penetrate the tissues faster than dry heat, but the chemical moist heat packs last for much shorter amount of time (about 6 hours) than chemical dry heat packs (Petrofsky et al., 2013). To determine which method of thermotherapy is more effective, 100 healthy individuals performed three sets of squats at 90 degrees or lower for five minutes with three-minute rest between to induce DOMS. They were then divided up into five groups randomly; control, moist heat immediately after exercise moist heap applied 24 hours after exercise, dry heat pack immediately after exercise, and dry heat pack 24 hours after exercise. One heat pack was applied to each leg over the quadriceps. The moist heat packs were applied for two hours and the dry heat packs were applied for eight hours. Pain was one of the variables measured using a ten-centimeter VAS where zero indicates "pain free" and ten indicates "very, very sore". Baseline measures were taken on a Monday before exercise, the exercise was performed Tuesday, and measurements were repeated on Wednesday, Thursday, and Friday. There was an increase in pain on Wednesday (one day post-exercise) in all the groups and peaked on Thursday (two days post-exercise), and the immediate moist heat pad group had the least amount of pain two days post-exercise in comparison to the other groups. This indicates that even though the immediate moist heat pack application was far less than the immediate dry heat, it has a greater effect on preventing and treating the pain associated with DOMS. Both of the immediate application of heat groups had a decrease in pain each day compared to the heat packs applied 24 hours post-exercise However, even though the heat pack groups all presented with less pain than the control group throughout the entire study, there were no statistical differences between the heat packs applied to the groups at 24 hours post-exercise and the control group. This indicates that any heat application is more effective than the control when treating pain associated with DOMS (Petrofsky et al., 2013).

Similar to thermal modalities, mechanical modalities have been studied as a potential treatment of DOMS vastly in the literature (Frey Law et al., 2008; Hilbert et al., 2003; Mancinelli et al., 2006; Zainuddin et al., 2005). Forty-four healthy participants performed eccentric wrist extension exercises in order to induce soreness in order to test the effectiveness of massage treatment on pain associated with DOMS (Frey Law et al., 2008). Each participant performed three sets of ten-pound eccentric contractions of wrist extension until fatigue with one to two minutes rest in between. The participants were then assigned to a deep massage group, superficial touch group, or control group. Each treatment was performed 48 hours post-exercise and lasted six minutes. The deep tissue massage consisted of a one-minute effleurage massage, followed by a four minutes petrissage, and finishing with a one-minute effleurage massage. The superficial touch group received six minutes of only effleurage massage on their skin. A thin layer of massage cream was put on the control group's arm but no further massage or touching was performed for the six-minute treatment period. Pain was assessed on a ten-centimeter VAS with zero indicating no pain and ten indicating the worst main imaginable during a stretch, at rest, and during a maximal contraction. These measurements were taken at baseline before the induction of DOMS, after the induction of DOMS, at 48 hours post-exercises before treatment, and after the six-minute treatment. Fray Law et al. (2008) concluded that a deep tissue massage significantly decreased pain during a stretch in the sore muscle in comparison to the light touch group and control group. However, none of the groups had varying results in resting pain (Frey Law et al., 2008). Similarly, Mancinelli et al. (2006) found significant decrease in perceived soreness in female college basketball and volleyball players who received a thigh massage in comparison to a group who received no treatment after the induction of DOMS. Twenty-two NCAA Division 1 female volleyball and basketball athletes were randomly assigned into a massage group of control group to receive treatment on the fourth day of practice when peak soreness was expected. Baseline measurements were taken before the first practice and on the fourth day of practice pre-treatment. Measurements were taken again after treatment. Pain was one of the variables measured using a VAS. On the fourth day of practice, the experimental group received a massage from one of two licensed massage therapists who utilized effleurage, petrissage, and vibration techniques for a total of 15 minutes. The control group received no treatment and were closely watched that they did perform any stretching or exercise during the 15 minutes. Eighty percent of the massage group participants reported feeling less sore after the massage with an average of five out of ten pain before massage and three out of ten pain post massage. The control group did not have a significant difference in soreness before and after the treatment period with an average of five out of ten pain before and after the treatment period. In conclusion, Mancinelli et al. (2006) reported a significant decrease in soreness post massage versus the control group. Additionally, Zainuddin et al. (2005) conducted a study to determine the effect of a ten-minute massage on DOMS soreness three hours after elbow flexor resistance training. Ten healthy subjects who do not participate in resistance training were recruited to participate in this study. Using an arm to arm comparison, subjects performed the same maximal eccentric exercises of the elbow flexors two weeks apart. The DOMS induction protocol involved six sets of ten repetitions of maximal eccentric contraction of the elbow flexors with three minutes of rest in between. Each participant had one control arm and one experimental arm. Pain was assessed on a 100mm VAS (0= no pain, 100- extremely painful) at baseline, before exercises, immediately after, exercises, and 30 minutes after exercise, as well as one, two, three, four, seven, ten, and 14 days post-exercises. Pain was assessed during passive range of motion of the elbow joint and during palpation of the brachioradialis and brachialis. A ten-minute sports massage consisting of effleurage and petrissage techniques was performed on the entire arm three hours after the exercise. Soreness peaked during palpation one to three days post-exercise and soreness during range of motion peaked at four days post-exercise. Soreness was gone by seven days post-exercise in all participants. There was a 20 to 40 percent decrease in soreness in the massage arm compared to the no treatment arm in the same individual in both range of motion and palpation, concluding that massage significantly decreased soreness in comparison to no treatment (Zainuddin et al., 2005). Similarly, Hilbert et al. (2003) tested the effect of a twenty-minute massage on DOMS. Eighteen participants performed six sets of eight maximal eccentric hamstring contractions in order to induce soreness with one minute of rest in between. They then performed five more maximal eccentric contractions. They were divided into a massage or control treatment group. Two hours after exercises, the participants received a 20-minute treatment of either massage using Swedish techniques including effleurage, petrissage, and tapotement or a sham treatment where placebo lotion was applied to the leg and the participant was informed to rest. Pain was one of the variables measured in at baseline, zero, two, six, 24, and 48 hours post-exercise. Pain was assessed on a Differential Descriptor Scale (DDS), which measures sensory and emotional aspects of pain using descriptors and 21 points in which participants mark their unpleasantness and intensity of soreness. There were no significant differences between treatments for unpleasantness. Both groups experienced significantly higher intensities of soreness at six, 24 and 48 hours post-exercise, but there was a significant decrease in the intensity of soreness at 48 hours post-exercise in the massage group. Hilbert et al. (2003) concluded a 20-minute massage utilized two hours after exercise decreased the intensity of pain and soreness caused by exercise 48 hours after the exercise (Hilbert et al., 2003). Massage is commonly supported throughout the literature as being an effective treatment for decreasing pain caused by DOMS (Frey Law et al., 2008; Hilbert et al., 2003; Mancinelli et al., 2006; Zainuddin et al., 2005) .

Nonsteroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen and diclofenac, are another common treatment those suffering from DOMS resort to for relief of pain (A. E. Donnelly et al., 1990; A. Donnelly et al., 1988; Grossman et al., 1995). Grossman et al. (1995) induced DOMS on 20 healthy male and female individuals who did not participate in upper extremity weight training in the past six months. Subjects were split into two groups, control and experimental. The experimental group was to intake 600 milligrams of ibuprofen four times a day for five days, where the control group was given placebo pills that looked identical to the ibuprofen four times a day for five days immediately following eccentric exercise of the elbow flexors to induce DOMS. Subjects completed three-second eccentric elbow extension contraction with an 11.34 kilogram weight until they could not control the weight any longer. The dumbbell was then reduced by 2.75 kilograms and the eccentric exercise was repeated until failure. The weight was once again reduced by 2.75 kilograms, and this continued until the weight was down to 2.75 kilograms and the participant was unable to control the weight, or they reached 30 repetitions at 2.75 kilograms. Pain was one of the variables measured during range of motion in full elbow flexion. A ten-centimeter VAS was used to assess the pain from no pain to unbearable pain. This measurement was taken at 24 hours pretest, 48 hours after the exercise, and 96 hours after the exercise. At 48 hours the ibuprofen group experienced an average of 5.7/10 pain and the placebo group reported an average of 4.4/10 pain. At the 96 hour assessment, the ibuprofen group reported an average pain of 3.65/10 where the placebo group reported 1.45/10 pain. The authors concluded there were no significant differences of soreness reported between the two groups and ibuprofen does not significantly effect the soreness associated with DOMS(Grossman et al., 1995). Similarly, Donnelly et al. (1988) induced DOMS on 20 untrained male participants who ran downhill for 45 minutes on a treadmill to induce DOMS in their legs. The participants were divided into two groups and took either diclofenac or a placebo pill before the exercise and for 72 hours. This protocol was repeated again ten weeks later on the same individuals. Pain was assessed before the exercise and at six, 24, 48, and 72 hours after each exercise. Subjects rated their front thigh, back thigh, buttocks, front lower leg, and back lower leg soreness. Pressure from a metal probe was also used to determine muscle soreness on the middle and either end of the muscle. Participants also rated their pain of their abdomen, shoulders, and arms. All pain was rated on a questionnaire using a scale of one to ten (1= normal, 10=very, very, sore). Overall, there was not a significant difference in soreness between the groups. However, there was a difference in pain between the two phases of this study. The first period of the study, the diclofenac group had reduced pain, but during the second period of the study, the placebo group had reduced pain. This interaction between treatment and period was a significant finding, but it cannot be concluded that diclofenac reduces the soreness associated with DOMS (A. Donnelly et al., 1988). Donnelly et al. repeated this study (1990), but the experimental group was given 600 milligrams of ibuprofen. Participants once again completed the 45-minute downhill run a total of two times, ten weeks apart. The ibuprofen or placebo pill was administered 30 minutes before exercise, and every six hours for 72 hours post-exercise. Pain was once again assessed before and after each run and six, 24, 48, and 72 hours after the run. The same scale was utilized for the same regions of the body as the previous study (front lower leg, back lower leg, front thigh, back thigh, and buttocks), minus the abdomen, shoulders and arms. The metal probe was used to determine pain with pressure on the same three points of the muscle. Soreness significantly increased in both groups after each downhill run.

Soreness from the probe in the middle of the back of the thigh was significantly decreased in the ibuprofen group. However, there was no significant difference in overall soreness between the two treatment groups or the two bouts of running (A. E. Donnelly et al., 1990). In conclusion, the use of NSAIDs to decrease the pain associated with DOMS is not supported in the literature (Donnelly et al., 1990; Donnelly et al., 1988; Grossman et al., 1995).

Various forms transcutaneous nerve stimulation have been studied for their effect on DOMS. The techniques include interferential therapy (IFT), high-volt pulsed current (HVPC), and microcurrent electrical neuromuscular stimulation (MENS) (Allen et al., 1999; Butterfield et al., 1997; Kim et al., 2011; Minder et al., 2002; Weber et al., 1994). IFT is one of the most common electrotherapeutic modalities, which consists of two alternating medium frequency electrical currents that work together to create a low frequency in order to reduce pain and provide therapeutic effects (Minder et al., 2002). Minder et al. (2002) induced DOMS on 40 individuals' elbow flexors to evaluate the effect of IFT. The participants eccentrically lowered their 1RM plus 0.5 kilograms for a count of three seconds into full extension. The experimenter then placed the weight and arm back in a flexed position. This was repeated until the participant could not control the weight or three seconds. Pain measurements were taken at immediately following the DOMS protocol, and before and after each treatment. Participants received treatment for five consecutive days. Pain was assessed using a digital ten-centimeter VAS with one end of the scale reading "no pain" and the other end reading "max pain". Pain was taken at rest, upon full extension of the arm sustained for ten seconds, pain at mechanical pain threshold (MPT) of 15 Newton's for ten seconds, and pain at (MPT) point five. The participants were divided into one of four groups consisting of control, placebo, IFT 1, and IFT 2. Each treatment lasted 30 minutes each day within one hour of the original DOMS induction time. Both IFT groups' parameters were set to bipolar, four kHz carrier frequency and 125 μs pulse duration. The IFT 1 group was treated with ten to 20 Hz and the IFT 2 group was treated with 80-100 Hz. The participants told the researchers when the current was "strong but comfortable" to determine the intensity. The rubber electrodes were placed three centimeters apart on the biceps brachii. The placebo group received the electrodes on the biceps but the machine was never turned on, and the control received no treatment. There was a common increase in pain in the elbow flexors after the DOMS protocol in every group. However, there were no significant differences between the groups at any point, indicating that IFT does not have an effect on reducing muscle soreness (Minder et al., 2002). HVPC is a form of electrical stimulation used in therapeutic settings to reduce pain (Butterfield et al., 1997). DOMS was induced on 28 college students in order to investigate the effects of a 30-minute HVPC treatments on the muscle soreness. A Cybex machine was utilized to create DOMS by performing concentric and eccentric knee extension. At 75% of their 1RM, participants performed 30 sets of ten repetitions of leg extensions lasting 20 to 30 seconds each with a 15 to 20 second rest period in between. Every eight sets, they were given a two-minute break. After the concentric phase was complete, subjects eccentrically loaded the quadriceps until they were too fatigued to lift 30 pounds. The 30 minutes HVPC treatment was administered at 24, 48, and 72 hours post-exercise. The participants were divided into two groups. The HVPC group received a 30-minute high-volt, twin-peak, pulsed electrical current at 125 pulses per second (pps) on the quadriceps. The sham treatment group had electrodes placed on their quadriceps with the machine on but the wrong channel connected so they felt no electrical stimulation. Pain was a variable measured in this investigation using a VAS. Measurements were taken at baseline and before and after each treatment. In both groups, pain peaked at 48 hours post-exercise, and both groups reported a significant decrease from pretest to posttest. This suggests the sham group felt reduced pain from a placebo effect. There were no significant differences in pain between the two groups, and neither of the groups had a decrease in pain from 24 hours to 72 hours after the DOMS induction. However, there was a significant pain decrease in both groups during the treatment. The pain returned after the treatment was complete. In conclusion, the HVPC treatment had no effect on reducing pain long term associated with DOMS (Butterfield et al., 1997). Allen et al. (1999) experienced similar results when comparing MENS to a sham treatment on DOMS. Subjects were assigned into one of two groups (MENS or sham) after inducing DOMS on their biceps brachii by performing eccentric bicep curls at 13.5 kg (men) or 11.25 kg (women), decreasing the weight by 2.75 kg until they were unable to control a 2.75 kg weight. A baseline measurement was taken before the protocol began, and once DOMS was induced the measurements were taken again immediately. Subjects returned for measurements every 24 hours for three more days. Pain was assessed on a graphic rating scale two times; while lifting their arm with a weighted Orthoplast sphere around the belly of the bicep and again while actively extending the elbow. The participants in the experimental group received a 20-minute MENS treatment 24, 48, and 72 hours after exercise. The first ten minutes of the treatment had an intensity of 200μa at a frequency of 30 Hz, which was then lowered to 100μa with a frequency of 0.3 Hz for the next ten minutes. The sham group received a fake treatment from a disabled machine, which produced no electrical stimulation. Pain increased in both groups after the DOMS induction protocol, but there were no significant differences between the groups, indicating MENS does not decrease the pain felt from DOMS (Allen et al., 1999).

A combination of treatments has also suggested to help with relieving symptoms of DOMS in the physically active. Isabell et al. (1992) induced DOMS on 22 participants who were split up into four treatment groups of a control, ice massage, exercise, and ice massage and exercises combined. Pain measurements were taken before exercises, and after each treatment on the Talag Scale. One means no pain, two means dull vague achy, three is slight persistent pain, four is more than slight pain, five means painful, six is very painful, and seven is unbearably painful. Subjects performed bicep curls at 90% of their ten-repetition max up for to 300 repetitions. Then, the participants received their assigned treatments at zero, two, four, six, 24, 48, 72, and 96 hours after the exercise. The control group rested for 15 minutes of no treatment. The ice massage group received an ice ball massage on the entire bicep with an ice ball in circular motions for 15 minutes. The exercises group performed mild full rang of motion with only gravity as resistance from flexion into extension of the elbow for 20 seconds, with 40 seconds rest for a total of 15 minutes. The ice massage plus exercise group received 20 seconds of the same rang of motion exercise followed by 40 seconds of ice cup massage for the 15 minutes of treatment. The ice and ice and exercise groups peaked soreness at rest at 48 hours and then decreased, where the exercise group peaked at 24 hours and maintained until 48 hours before decreasing. The control group peaked soreness at the 96 hour assessment before decreasing Although each group had significant decreases in pain over time, in comparison to the control group, the ice massage, ice massage with exercises and exercises alone did not significantly decrease the pain associated with DOMS (Isabell et al., 1992).

DOMS can be induced for research purposes by performing eccentric and concentric exercises in a controlled environment (Clarkson & Tremblay, 1988; Fonda & Sarabon, 2013; Lau, Blazevich, Newton, Xuan Wu, & Nosaka, 2015). Many researches have examined various treatment strategies ability to improve symptoms of DOMS, including muscle function and pain. However, the effects of cupping have not yet been studied on pain associated with DOMS.

Massage

Massage is a technique used in many different settings as a treatment thought to relieve muscle soreness and pain, either acute or chronic. Many researchers (Farr, Nottle, Nosaka, Sacco, 2002; Hilbert et al., 2003; Jakeman, Byrne, Eston, 2010;

Micklewright, 2009; Rodenburg, Steenbeek, Bar, 1994; Smith, Keating, Holbert, Spratt, McCammon, 1994; Wenos, Brilla, Morrison, 1990) have examined the effects of various massage techniques on induced delayed onset muscle soreness including effleurage, tapotement, petrissage, and compression. Strength and soreness were the most common factors studied once DOMS was induced and massage was applied.

Majority of the researchers found that some sort of massage applied to a treatment group for 15 minutes or more after the inductions of DOMS significantly decrease muscle soreness compared to the other groups in the study (Farr et al., 2002; Frey Law et al., 2008; Hilbert et al., 2003; Jakeman et al., 2010; Mancinelli et al., 2006; Rodenburg, Steenbeek, & Bar, 1994; Smith, Keating, Holbert, Spratt, & McCammon, 1994; Zainuddin et al., 2005). After DOMS was induced on the forearm flexors during a 30-minute exercise protocol, a 15-minute massage was performed on the treatment group of Rodenburg and colleagues' participants. In comparison to the control group who received no treatment, the treatment group had significantly lower soreness (Rodenburg, Steenbeek, Bar, 1994). Similarly, a 20 minutes massage (five minutes effleurage, one minute tapotement, 12 minutes petrissage, and two minutes effleurage) on participants' hamstrings two hours after a DOMS induction protocol, soreness was lowered at 48 hours after exercise comparatively to a control group receiving a sham massage (Hilbert et al., 2003). Farr et al. and Smith et al. also discovered that soreness was decreased after 30 minutes of petrissage and effleurage massage on elbow flexors (Smith et al. 1994) and legs (Farr et al., 2002) in comparison to no treatment. Zainuddin et al. (2005) found that soreness also significantly decreased in the massage group after a ten-minute massage on sore biceps three hours after exercise compared to no treatment. Likewise, Mancinelli and colleagues (2006) concluded that soreness on basketball and volleyball players' quadriceps was significantly improved after 17 minutes of effleurage, petrissage, skin rolling and vibration after preseason training. Finally massage and compression demonstrated to reduce soreness significantly more than passive recover and compression in the lower body after plyometric exercises (Jakeman et al., 2010).

Comparatively, Wenos et al. (1990) and Mickelwright et al. (2009) concluded that massage does not combat muscle soreness. Wenos et al. (1990) used massage techniques after resisted eccentric knee extensions on the quadriceps and found no significant improvements on soreness compared to no treatment. Similarly, Mickelwright et al. (2009) found that soft tissue releases only made the soreness caused by DOMS to increase after four sets of 20 eccentric elbow extensions.

Massage techniques performed muscles suffering from DOMS was less commonly effective on the increase in strength once compared to another group (Farr et al., 2002; Hilbert et al., 2003; Micklewright, 2009; Zainuddin et al., 2005). However, Rodenburg et al. (1994), Mancinelli et al. (2006), and Jakeman et al.'s (2010) findings support the hypothesis stating massage may improve the decreased strength DOMS causes to a muscle. Jakeman et al. (2010) determined that a 30-minute massage and compression on the lower body after 100 plyometric drop jumps were performed improved the lack of function and power lost from DOMS compared to a passive recovery group. Likewise, Mancinelli et al. (2006) found that participants had an increased vertical jump after a 17-minute massage including effleurage, petrissage, skin rolling, and vibration on the sore quadriceps muscles in comparison to a control group. And finally, Rodenburg et al.'s (1994) treatment group included participants who received a 15 minutes massage utilizing techniques of tapotement, petrissage, and effleurage along with a warm up and stretch. The control group did not receive these treatments. The treatment group demonstrated a significantly increased force production and decreased soreness compared to the control group.

Cupping Therapy

Cupping therapy may improve pain, function, and ROM in individuals with nonspecific low back pain (Markowski et al., 2014). Twenty-one participants were included based on specific criteria to the study, aged from 30 to 56 years, and had nonspecific low back pain for at least two years (Markowski et al., 2014). Each participants received the cupping therapy treatment after baseline testing (Markowski et al., 2014). Outcome measures included level of function based on the Oswestry Disability Questionnaire, pain on a VAS and pain diagram, low back range of motion using an inclinometer in lumbar flexion, extension, and lateral flexion, straight leg raise using an inclinometer and tenderness to the touch (Markowski et al., 2014). After baseline testing, the 4 cups were placed on the lumbar spine for ten minutes. Outcome measures were taken again and compared to baseline. Significant differences presented after treatment in

VAS scores, single leg raises on the left leg, and increased lumbar flexion range of motion and tenderness to the touch, indicating that the cupping therapy improved the condition of low back pain (Markowski et al., 2014).

Research also suggests that cupping therapy may have a significant impact on alleviating chronic neck pain (Chi et al., 2016; Cramer et al., 2011; Lauche et al., 2011, 2013). Dry cupping executed every three to four days for five total treatments may decrease pain and improve function in patients with chronic neck pain (Lauche et al., 2011). When utilized on participants 18 to 75 years old who are suffering from neck pain at least five days a week for at least three months, there were significant differences in outcomes compared to the control group, who were said to be on a waiting list. Pain at rest and with movement, function measured on neck disability index (NDI), and pain pressure threshold (PPT) were just a few of the outcomes in which suggested significant improvements after the installation of cupping therapy (Lauche et al., 2011). Another form of dry cupping, which uses fire to create a vacuum suction, was examined in comparison to a control group on chronic neck and shoulder pain (Chi et al., 2016). Participants either received fire cupping for 20 minutes or rested for 20 minutes (Chi et al., 2016). Between groups, there were significant differences in favor of the cupping therapy (Chi et al., 2016). Cupping therapy produced a significantly increase in skin tissue temperature and decrease in pain on a Visual Analog Scale (VAS) in both the neck and shoulder (Chi et al., 2016). Finally, pulsating cupping therapy may improve pain and function in individuals with chronic neck pain compared to standard medical care (Cramer et al., 2011). When implemented every three to four days for two weeks, pulsating cupping therapy demonstrated a significant decrease in pain, pressure pain threshold, neck disability, and pain at motion as well as a significantly improved quality of life compared to the control group (Cramer et al., 2011). Although these techniques varied, overall cupping therapy may improve function and decrease pain associated with chronic neck pain.

Massage cupping, or sliding cupping, may also be beneficial in decreasing symptoms associated with chronic neck pain (Lauche et al., 2013) and spondylosis (Hong, 2000), as well as other conditions such as respiratory system diseases, digestive system diseases, lumbar pain, and other issues effecting other parts of the body (Hong, 2001). Massage cupping was compared to progressive muscle relaxation (PMR) in a study conducted by Lauche el al. (2013), where home based cupping therapy demonstrated improvements on chronic neck pain (Lauche et al., 2013). After learning how to cup massage themselves in a workshop, participants suffering from chronic neck pain provided themselves with two treatments a week (Lauche et al., 2013). Cupping massage involved a movement of the cups while on the skin in order to improve circulation and lymphatic drainage (Lauche et al., 2013). The control group was instructed on progressive muscle relaxation techniques and was to practice two times a week as well (Lauche et al., 2013). Outcome measures included pain on a VAS, measure pain with motion, quality of pain, functional disability, psychological distress, wellbeing, health-related quality of life and pressure pain sensitivity on a VAS, as well as a daily log to record intensity of pain, the patients expectations on a VAS, and any adverse reactions. Measurements were taken at baseline and at week 12. Treatments were self-administered by the participant twice a week for 12 weeks at home. Both groups had a significant decrease in pain from baseline to 12 weeks (Lauche et al., 2013). The only significant differences between the groups included pain pressure threshold and overall wellbeing, with favor to cupping massage therapy, suggesting that cupping massage had a greater effect on chronic neck pain then PMR treatments (Lauche et al., 2013). Similarly, massage cupping presented benefits in 100 patients treated who were suffering from neck pathologies for three months up to 13 years. The neck pathologies included general neck pains, vertebral artery pathologies, and nerve root pathologies. Sixty-nine of these cases had a straightened physiological curvature of the cervical vertebrae and 23 cases had insufficient blood supply of the vertebrobasilar artery. Each of these individuals received a massage cupping treatment once or twice a week on their neck with liquid paraffin wax as the lubricant until petechiae was present. All participants experienced a decreased in symptoms after the first treatment, with symptoms disappearing after one month in 46 cases. Thirty-six cases reported most of their symptoms resolving, 15 reported improvement, and three reported no significant change. Forty-five cases showed improvements of the physiological curvature in the cervical spine after one month via x-ray. Additionally, twenty cases presented with improved vertebral artery blood supply via rheoencephalogram. These results indicate a cupping massage to the effected area improve pathologies associated with the cervical spine (Hong, 2000). Additionally, sliding cupping is suggested to be effective in treating other aliments of the body (Hong, 2001). A 32 year old woman who suffered from a low fever for three months and was unable to receive a diagnosis underwent three cupping massage treatments over specific acupuncture points of the neck and back, reducing her fever to normal. A young boy experienced similar results when he was suffering from emaciation and chronic indigestion after just five treatments of cupping massage on specific acupuncture points. He gradually increased his weight and appetite and after three months was back to normal health (Hong, 2001). Additionally, two treatments of cupping massage was able to restore hearing in a man who suffered from sudden deafness and tinnitus after an acute bout of anger (Hong, 2001). Finally, a 42-year-old women who suffered from acute back pain experienced improvements in pain after just one treatment of cupping massage. She was completely back to normal after two treatments with no pain (Hong, 2001). These case studies suggest that when applied appropriately, cupping massage may have benefits for a variety of injuries and aliments after just a few treatments (Hong, 2001).

The benefits of cupping have been reported on nonspecific chronic muscle disorders such as neck and back pain (Akbarzade et al., 2016; Akbarzadeh et al., 2014; Chi et al., 2016; Cramer et al., 2011; Ge et al., 2017; Lauche et al., 2011, 2013, 2016; Lee et al., 2010; Markowski et al., 2014). However, there is limited literature addressing the effects of cupping massage. Only a few case studies (Hong, 2000, 2001) have been reported as well as one study addressing cupping therapy on DOMS (Hong, 2000, 2001; Lauche et al., 2013).

Overall, it appears that massage cupping could potentially be useful in relieving the pain associated with DOMS. It has not, however, been addressed yet in the literature. The purpose of this research is to address the effects of massage cupping therapy on the pain associated with DOMS.

CHAPTER III

METHODS

Study Design

The design of this study was experimental, repeated measures design, with participant stratification to allow equal representation of gender between groups and single blinding of the participants. Participants were given one of two interventions after the induction of DOMS, with measurements taken at baseline and after DOMS induction, and before, during and after the treatment. The independent variables were treatments (petrissage and cupping massage) and time (before, during and after treatments). The dependent variable measured was pain on an 11-point numerical rating scale (NRS) from zero to ten (0 being no pain, 10 being the most pain).

Participants

Thirty-two individuals (13 males, 19 females) with no previous injury of the biceps were included in this study. Participants who volunteered were recruited on a Division I university campus via classroom presentation explaining the study participation opportunity. Potential recruits were all given a slip of paper to fill out name and contact information and to check a box if they were interested in participating. All potential participants turned in the papers and those interested were contacted. Participants' age ranges from 18 to 22 years. Participants were asked to provided informed consent prior to participation in accordance with the University's institutional review board. While participating, participants were asked to refrain from taking any pain medication, exercising, or receiving any additional therapies during the study. Volunteers were excluded from the study if they presented with any contraindications of cupping therapy, had a history of biceps injury that effected their arm function, reported a history of rhabdomyolysis or an allergy to grape seed oil. Means and standard deviations for the participant's height and weight are categorized by the intervention group in Table 1.

Table 1. *Participant Demographics*

Group	Participants	Male	Female	Age (yrs) (±) SD	Height (cm) (±) SD	Weight (kg) (±) SD
Cupping	16	8	8	20.19 ± 1.28	171.29 ± 11.35	72.21 ± 14.40
Petrissage	16	5	11	20.31 ± 0.95	174.30 ± 10.85	75.69 ± 16.66
Total	32	13	19	20.25 ± 1.11	172.78 ± 11.03	73.95 ± 15.42

Outcome Measures

Pain was the primary outcome measure assessed via a NRS (AlBedah et al., 2015). Pain was assessed before the DOMS induction protocol, immediately after the DOMS induction protocol, and then immediately prior to, during, and immediately after each treatment (48, 72, 96, 120, and 144 hours post-induction) until pain was rated as zero.

Procedures

Data was collected at baseline, after the onset of DOMS, and before, during, and after the treatment sessions at 48, 72, 96, 120, and 144 hours post induction, or until pain was reported at zero.

DOMS Induction

After obtaining consent, a medical history, and a baseline measurement for pain, the process of DOMS induction began. Using the NRS, participants were asked to rate their current pain, if any in their bilateral bicep muscle at rest and during one set of three bicep curls at five pounds.

The induction of DOMS protocol was adapted from DOMS induction protocols used in previous literature (Schoulz, Snyder, Evans, & Lund, 2014; Kuligouski et al, 1998; Weber et al, 1994). Participants performed arm curls on a seated arm curl bench in order to prevent hyperextension of the elbow and to better isolate the bicep muscle. The DOMS induction protocol was performed on the participants' nondominant arm's bicep muscle. Each participant's one repetition maximum (1RM) was established for bicep curls to be used as the starting weight. Once 1RM was established, 2.27 kg were subtracted and the induction protocol began. First, participants performed two sets of concentric bicep curls until failure with the starting determined weight, with 30 seconds of rest between the sets. Once they reached failure during the second set, they had one minute of rest. Next, 2.27 kg were added to participant's 1RM and eccentric arm curls were performed for five sets of ten repetitions. The eccentric curl began in full elbow flexion moving into full extension over five seconds. Once in full extension, the weight was removed from the participant's hand and the elbow was passively placed into flexion again. This was repeated for five sets of ten repetitions at the starting weight, with one-minute rest between each repetition. When the participant was unable to control the contraction for five seconds, the repetition was considered to have reached failure. Finally, once failure of eccentric curls was achieved, the weight was reduced by 2.27 kg and they continued the set. Once all five sets were completed, participants immediately rated their pain at rest bilaterally on the NRS following the induction of DOMS protocol.

Confirming DOMS

Patients returned as close to 48 hours as possible after the first session to confirm they have obtained DOMS. They performed one set of three bicep curls at 2.27 kg and rated their pain. If pain was higher than baseline, DOMS was confirmed. Once DOMS was confirmed, participants were randomly divided into one of two treatment groups, with 16 participants per group.

Treatment Groups

Participants were stratified into two treatment groups; cupping massage group (treatment 1) and a petrissage group (treatment 2). Stratification was performed to create heterogeneous groups based upon gender. Participants were not informed as to what group they were assigned too.

Cupping Massage Application

A certified athletic trainer who is certified in cupping therapy performed the cupping massage with one silicone massage cup applied to the biceps. Grape seed oil was applied as lubrication and one of four different sized silicone cups was used. The cupping therapist attached the cup to the skin by applying pressure with thumbs down the center of the cup while the rim of the cup was placed on the participants arm. Once suction was achieved, the therapist moved the cup proximal to distal, and distal to proximal, back and forth with one hand for ten minutes, using opposite hand as an anchor. A curtain was drawn so the participant could not see what treatment was being performed.

Petrissage Application

Petrissage was performed on the involved bicep by the same certified athletic trainer that did the cupping therapy for 10 minutes. Grape seed oil was applied as lubrication. The certified athletic trainer used the lifting and rolling technique to perform massage proximal to distal end of bicep and back for five minutes. A curtain was drawn to prevent the participant from seeing the treatment being performed

Data Analysis

The data analyses was completed using IBM SPSS Statistics, Version 22 (IBM Corp, Armonk, NY). Descriptive statistics were reported for participant demographics and mean values were reported for all pain scores (Table 2). Participant survey summaries were reported qualitatively (Table 3). A 2 (session) x 2 (group) repeated measures ANOVA was used to determine if DOMS was induced and if the two groups reported different levels of pain, prior to beginning the first session. Independent t-tests were used to determine if there was a difference between massage conditions: 1) prior to each session, 2) during each session, 3) and immediately following each session (Table 2). For all inferential statistics, the level for statistical significance was set at $p < .05$, with a Bonferroni adjustment used for the t-test analysis (alpha = 0.05/4 = 0.0125) when appropriate. Once a participant reported their pain as a “0” on the NRS, the remaining data entries were treated as missing values. For example, if a participant reported no pain at the beginning of session four, they were released from the study and all of their subsequent data points for session four, as well as five and six, were entered as missing data.

Results

The repeated measures ANOVA revealed a significant difference in pain reported prior to the DOMS session and prior to the first treatment session ($F(1, 30) = 140.90$, $p < 0.001$), but no session by group interaction $(1, 30) = 0.31$, $p = 0.58$). Participants reported a significant increase in pain 48 hours after the induction of DOMS, however there was no difference between the petrissage and cupping groups (session * group) immediately prior to the first intervention. We therefore concluded that DOMS was induced and the groups were the same prior to before the first treatment was applied. The independent t-tests indicated that the levels of pain reported by the cupping and the massage groups were not different immediately before treatment sessions 1 - 4 ($p > 0.05$), during treatment sessions 1 - 4 ($p > 0.05$), and immediately after treatment sessions 1 - 4 ($p > 0.05$). Means and individual t-test results are reported in Table 2. During the participants' last session, they were asked if they believed the treatment which they received was effective at managing their pain. Thirty-one of the participants (97%) reported that the treatment they received was effective at managing their pain.

Table 2. *Descriptive statistics for pain scores and t-test values.*

Time - Session	Pain Scores: Petrissage $\bar{x}$ ± SD (N)	Pain Scores: Cupping $\bar{x}$ ± SD (N)	Independent t-test results
Pre - 1	3.84 ± 1.77 (16)	3.5 ± 1.71 (16)	t(30) = -0.56, p = 0.58
Pre - 2	2.44 ± 1.59 (16)	2.13 ± 1.41 (15)	t(29) = -0.56, p = 0.58
Pre - 3	0.93 ± 1.39 (15)	0.97 ± 1.08 (15)	t(28) = 0.07, p = 0.94
Pre - 4	0.67 ± 1.21 (6)	0.11 ± 0.33 (9)	t(13) = -1.33, p = 0.21
During - 1	2.13 ± 1.67 (16)	2.38 ± 1.63 (16)	t(30) = 0.43, p = 0.62
During - 2	1.63 ± 1.59 (15)	2.29 ± 1.59 (14)	t(27) =-1.12, p = 0.69
During - 3	2.33 ± 1.21 (6)	1.50 ± 1.33 (10)	t(14) = 0.25, p = 0.76
During - 4	*	3.0 (1)	*
Post - 1	1.78 ± 1.25 (16)	1.84 ± 1.48 (16)	t(30) = 1.29, p = 0.47
Post - 2	1.00 ± 1.13 (15)	1.39 ± 1.16 (14)	t(27) = 0.92, p = 0.29
Post - 3	0.67 ± 0.82 (6)	0.78 ± 0.83 (9)	t(13) = 0.26, p = 0.91
Post - 4	*	0.0 (1)	*

*Could not be computed because at least one group was empty.

CHAPTER IV

DISCUSSION

My results indicate that cupping therapy and massage therapy did not differ in their effect on reducing the pain associated with DOMS. All participants felt significant relief of DOMS by the fourth treatment, which was five days (120 hours) post the initial DOMS induction. However, DOMS generally resolves itself within 96 hours (Bakhtiary et al., 2007). Since I did not incorporate a control group in my study, I can only compare the recovery of my participants to previous research addressing DOMS recovery. Therefore, it may be assumed that either the two treatments were ineffective in enhancing DOMS recovery, or that they were both equally effective. However, during the treatment, several participants receiving the cupping massage actually reported an increase in pain, although these differences were not significant.

One issue that warrants discussion is the negative response that some of the participants had to the cupping treatment. There are two points to consider here. First, any novel intervention should be investigated for potential negative effects that patients could experience. When making clinical decisions using evidence-based practice, the efficacy cannot be the only validation for choosing and implementing a treatment on a patient (Haynes, 2002; Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996; Sargent, 2010). The treatment must be appropriate for the situation, injury, or condition, and the patient must be gaining some benefit from it, more so than risks (Straus & Sackett, 1998). Utilizing previous research and case studies to support the desired outcome is one way to make a clinical decision, but each situation must be individualized in order to make a decision that is best suited for the specific patient (Straus & Sackett, 1998).Therefore, if cupping therapy is uncomfortable for a patient, it would be best to choose a different treatment option for that specific individual.

Second, the protocol that I used for the massage cupping could have caused the increase in pain reported by several of the participants, as two participants receiving the cupping treatment complained of discomfort during treatment. This may have to do with treatment time. Each treatment was ten minutes long, as previous research has suggested an average of ten minutes for cupping treatments (Akbarzade et al., 2016; Chi et al., 2016; Cramer et al., 2011; Ge et al., 2017; Lauche et al., 2011, 2012, 2016; Markowski et al., 2014; Michalsen et al., 2009; Teut et al., 2012). However, Hong (2000) only performed cupping massage until petechiae appeared. Hong (2000) reported only giving treatment every three to five days. In the present study, participants received the treatment every day. However, since there is limited science to support the length of message cupping protocols, I chose to keep the length of both massage techniques consistent. This may have led to discomfort to the touch and irritation to the treated area. Perhaps if the treatment length would have been more individualized to each participant, it would have had a beneficial effect, or at least avoided discomfort during the treatment.

In comparing my results to previous research, effleurage and petrissage have been supported as an effective modality for reducing the pain associated with DOMS (Ogai et al., 2008; Zainuddin et al., 2005). The present study did not compare the treatment to a control as previous research has (Ogai et al., 2008; Zainuddin et al., 2005). However, cupping therapy had no difference than petrissage in reducing pain from DOMS. If previous research supports the use of effleurage and petrissage to alleviate DOMS, perhaps cupping therapy can alleviate it as well, considering there was no difference in the results. Mancinelli et al. (2006) implemented effleurage and petrissage treatment in an attempt to relieve pain with DOMS measured on a VAS on collegiate basketball and volleyball players' quadriceps on the fourth day (72 hours) post training, which was the predicted peak of soreness date. One group of athletes received the massage, while the other group, the control group, rested for the same amount of time (Mancinelli et al., 2006). The massage group experienced significant decreased soreness compared to the control group immediately following the treatment (Mancinelli et al., 2006). The participants in my study experienced soreness at 72 hours post-exercises, just as those in Mancinelli et al.'s (2006) research. Similarly, massage and cupping both decreased pain. My measurements were taken at pretreatment, during treatment, and post treatment, and compared at 24 hours apart. In contrast, Mancinelli et al. (2006) took measurements at baseline, 72 hours post-exercise, pretreatment, and 72 hours post-exercise post treatment. However, massage decreased the pain in both massage groups in both studies, and in the cupping group, where the control group did not have a significant decrease in pain (Mancinelli et al., 2006). These similar results indicate that in comparison to a control, cupping massage would have decreased the pain associated with DOMS. Additionally, Frey Law et al. (2008) studied the effects of superficial touch massage and deep tissue massage treatment on DOMS. Similar to my study, DOMS was inducted on the upper extremity, however Frey Law et al. (2008) had participants perform a wrist extension protocol on visit one. Similarly to my research, the participants returned at 48 hours post-exercise, where pain was assessed on a VAS (Frey Law et al., 2008). Deep massage was then implemented on one third of the participants, one third of the participants received a superficial massage, and the other third received no treatment (Frey Law et al., 2008). Results concluded that the deep tissue massage significantly decreased the pain caused by DOMS in comparison to the control group. Just as in my study, measurements were taken at baseline before and after exercise and before and after treatment, however, participants only returned for one treatment (Frey Law et al., 2008). In contrast to my research, participants only received a 6 minute treatment, where my participants underwent 10 minutes of treatment (Frey Law et al., 2008). Two different massage techniques were utilized as well (superficial and deep) (Frey Law et al., 2008), where I implemented petrissage and cupping massage. Although previous research implemented different DOMS protocols, parameters, techniques of massage, and treatment frequencies, my research supports the idea that petrissage and cupping massage may have both decreased the pain of DOMS compared to no treatment.

Previous research also suggests that the pain from DOMS may have alleviated itself without the use of treatment. Hilbert et al. (2003) randomly assigned participants to a massage or control group after inducing DOMS on the right hamstring with eccentric contractions. Participants received 20 minutes of either massage treatment or the sham treatments two hours after the DOMS induction. Authors measured peak torque, mood, ROM and soreness at two, three, 24, and 48 hours after exercise. The massage group, which received a combination of tapotement, effleurage, and petrissage, experienced a significant decrease in intensity of soreness at 48 hours post-exercise compared to the control group (Hilbert et al., 2003). In comparison, my protocol induced DOMS on the biceps muscle with eccentric and concentric contractions, and treatment wasn't implemented until 48 hours later. Pain increased from baseline at 48 hours post-exercise, similarly to the control group in the research presented by Hilbert et al. (2003). Like the control group, my participants had not yet received any interventions, demonstrating the effect of massage on DOMS compared to no treatment. One could conclude that without an intervention, the soreness will increase with time. Additionally, DOMS will generally alleviate itself by 96 hours post-exercise (Bakhtiary et al., 2007). All the participants in my study were at zero out of ten on the NRS by 96 hours post-exercise. This may suggest that the natural history of DOMS, which is the natural progression that a pathology or injury will take and its response to treatment, may have had an effect on my participants' recovery from DOMS (Brownson & Petitti, 1998). The interventions implemented in my research may have both exasperated the relief of DOMS better than the absence of treatment, but it is important to recall that DOMS will also resolve on its own in time.

As previously mentioned, neither the massage or cupping treatment had a significant adverse effect on the participants, indicating that the treatments most likely were not counter effective. In fact, almost all of the participants (97%) expressed that they felt the treatment was effective in relieving their pain when asked in the exit interview. Perhaps cupping and massage would have both exasperated the relief of DOMS in comparison to a control, however, it is cannot be determined for certain. The natural history of the injury of DOMS itself must also be considered.

My research and previous research may support the notion that cupping massage could help with the reduction of chronic and acute pain. Static cupping has significantly reduced chronic pain in the injured population (Akbarzade et al., 2016; Akbarzadeh et al., 2014; Chi et al., 2016; Cramer et al., 2011; Ge et al., 2017; Lauche et al., 2011, 2013; Lee et al., 2010; Ullah et al., 2007). However, previous research has not addressed the theories of why cupping therapy may be reducing the pain. The increase in tissue temperature from cupping therapy may be a factor as to why cupping therapy reduces pain (Chi et al., 2016). Skin temperature was measured with an infrared camera after a 20 minute cupping treatment on chronic neck and shoulder pain, which resulted in a significant increase in temperature and a significant decrease in pain compared to no treatment (Chi et al., 2016). An increase tissue temperature may indicate an increase in blood flow through area treated, which is associated with vasodilation, then exasperating the metabolism of waste and toxins from the blood, therefore increasing healing and decreasing pain (Chi et al., 2016). Additionally, DOMS may be caused by the buildup of lactic acid in the blood (Haensel et al., 2012; Isabell et al., 1992). If cupping therapy increases the blood flow and creates vasodilation, the higher blood flow may help to move the lactic acid out of the affected area. However, research is lacking to support the actual cause of the decrease in pain.

There is a lack of research on massage cupping, and there is no known research on massage cupping on DOMS. I decided to implement cupping massage on DOMS, as the lack of research would not justify the ethical issue of treating those acute injuries with cupping massage. It would be inappropriate to implement a treatment on an acute injury, as there is evidence that suggests the treatment increases inflammation. Experimenting on DOMS, which is low level acute muscle injury (Haensel et al., 2012), is more ethical and the risks don’t outweigh the potential benefits of utilizing the treatment. Additionally, there is no evidence that supports the benefits of cupping therapy, therefore those patients seeking the relief and treatment of pain may not receive the outcomes they desire. Using participants who are not actively seeking relief of pain and inducing a low grade muscle injury was an appropriate way to examine the potential benefits of cupping massage.

Limitations

There were a few limitations of this study. As pain was the primary outcome measure, other important changes may have occurred that were not addressed. Although pain is a valid and important measurement, it represents a subjectively reported variable. Pain can vary among different people and perhaps objective and functional measurements would provide more thorough results. Additionally, some participants participated in weight training exercises before and during the study. This may have provided differences in soreness and how fast the pain was alleviated. And finally, primary investigator was still aware of the treatment while collecting the pain rating. Additionally, although the participant could not see which treatment they were receiving, they could still feel the treatment, perhaps revealing the sensation of a silicone cup or hands. This could have led to bias in the results.

Future Research

Limitations of this study should be considered for future research. Perhaps in future studies, functional measures could be taken such as elbow extension range of motion and girth measurements of the bicep. Additionally, the inclusion of participants with untrained arms that do not regularly exercise or weight train should be considered.

Future research should also focus on the treatments of cupping massage and petrissage versus a control group. The length of treatments should be investigated as well. Perhaps a more individualized treatment would have produced different outcomes. Finally, future research should examine the effects of these treatments on acute injuries as opposed to DOMS. DOMS is a lower grade acute muscle injury (Haensel et al., 2012). Perhaps examining the effects of these therapies on more extensive injuries would provide different results.

In conclusion, cupping massage is equally as effective as petrissage in reducing the pain associated with DOMS. However, one therapy cannot be supported over the other based on my research. Both cupping massage and petrissage groups experienced similar results, and future research is needed to determine which treatment would be more beneficial for a clinician to utilize on a patient suffering from DOMS. Pain is a personal experience and seemed to be resolved in almost all cases in my study from the treatments. This indicates that implementing cupping therapy or massage therapy may be better than doing no treatment at all, as both provided temporary immediate relief.

APPENDIX A

EXTENDED METHODS

Appendix A1. Informed Consent

UNIVERSITY OF NORTHERN IOWA
HUMAN PARTICIPANT REVIEW
INFORMED CONSENT

Project Title: The effect of massage therapy on pain associated with delayed onset muscle soreness

Name of Investigator(s): Carli Mueller, Dr. Todd Evans, and Dr. Tricia Schrage

Invitation to Participate:

You have been invited to participate in a research study conducted by Carli Mueller as part of a thesis project for completion of a Master's of Science Degree in Athletic Training. Your decision to participate in this study is entirely voluntary. Please read the information about the study below and be sure you understand it entirely before deciding whether or not to participate.

You have been asked to participate in this study because you are between the ages of 18-25, healthy, physically active, and are not currently participating in an arm weight training program that includes bicep curls. You will be excluded from the research study if you are pregnant or have or have ever had cardiac disease malignancy/cancer, tuberculosis, rhabdomyolysis, an injury to your biceps muscles or surgery in the past 6 months, blood clotting disorders, allergy to grapeseed oil , or have ever had severe negative effects from weight lifting. Additionally, you will be asked to refrain from exercise for the duration of this study (7 days maximum).

Nature and Purpose:

The purpose of this study is to investigate the effects of massage therapy on pain that is associated with delayed onset muscle soreness (DOMS). If you decide to participate, you will be asked to induce muscle soreness by performing single-arm biceps curls to the point of biceps muscle exhaustion on the first day. After DOMS has set in (about 48 hours after), you will report back for treatment. During this time, you will receive one of two different treatments on your bicep muscle.

Explanation of Procedure:

If you chose to volunteer to be a participant in this study, you will be asked to do the following:

1. Report to the Athletic Training Research Laboratory dressed in shorts, t-shit, and athletic shoes for a minimum of 2 sessions, maximum of 6 sessions. The first session will last approximately 1 hour. Sessions 2 through 6 will last approximately 30 minutes each session.

Appendix A1. Informed Consent (Continued).

2. During the first session:
    a. You will fill out a questionnaire about your health history to ensure that it is safe for you to participate in this study. You will then be informed of the possible risks of participation in this study. Based on your health and injury history, you may not be able to participate in this study. We will then review the following procedures with you:
    b. Next you will be asked to perform two bicep curls with a 5lb weight and to circle a number on a line to indicate your pain level from this exercise
    c. Using your non-dominant arm, I will determine your 1 repetition maximum (1RM). This will be determined by performing 1 curl with weight using dumbbells with increments increasing by 5lbs. Your 1RM will be determined as the weight that you are unable to curl once, minus 5 lbs.
    d. Next, the DOMS inducing protocol will be administered. This will involve 2 steps:
        i. Once your 1RM is determined, 5 pounds will be subtracted and this will be your starting weight. You will perform two sets of concentric bicep curls without assistance until failure, with 30 seconds rest in between.
        ii. Then you will have one-minute rest, followed by 5 sets of 10 repetitions of eccentric, or “negative”, bicep curls. Your starting weight will be your 1RM plus 5 pounds. I will move your elbow into full bent (flexed) position, hand you the weight, and then you will slowly lower the weight while straightening (extending) your elbow over 5 seconds. If you are unable to complete a repetition, the weight will be decreased by 5 pounds and you will continue repetitions of curls until you reach the 10 repetitions set. You will have one-minute rest. You will then complete 4 additional sets of the same type of eccentric bicep curls; slowly extending your elbow, failure, reduced weight, continue until 10 repetitions, and then a one-minute rest. This will continue until you reach 50 repetitions total or you reach muscle failure at 5 pounds.
    e. After this DOMS inducing protocol, you will be asked to again rate your pain. We will then schedule your second session. This session will occur as close to 48 hours as possible, after the first. Treatment sessions will occur as close as possible to 48, 72, 96, 120, and 144 hours after the DOMS induction protocol.
    f. After you complete the DOMS protocol, we ask that you avoid:
        i. Participating in any exercise including weight lifting and cardiovascular activity during the duration of this study (approximately seven days).
        ii. Using any other pain-relieving techniques, such as pain

Appendix A1. Informed Consent (Continued).

medications (e.g. Advil, ibuprofen, aspirin, Tylenol, etc.) or treatments such as hot or cold packs for the duration of this study

3. For the second and remaining sessions, you will return to the research laboratory and you will:
   a. Answer a series of precautionary questions
   b. Rate your pain on a line from 1- 10.
   c. Be administered one of two different types of massage therapy treatments. Each treatment will last 10 minutes. First, grapeseed oil will be applied over your biceps area. Both types of massage treatments will involve a kneading-lifting-rolling of the skin. One technique will be applied by hand (my fingers will do the skin liftng-rolling); the other technique will use a small, silicone, suction cup-like device (referred to as “cupping”). You will receive the same treatment for the duration of the study in sessions 2-6.
   d. During and after each treatment, you will again be asked to rate your pain.
4. Once the last treatment session is complete, you will be given an exit questionnaire, which will allow you to give me your feedback on the treatment and how you well you thought it worked on your pain/soreness.

Discomfort and Risks:

1. You will experience mild to moderate pain from the bicep curl DOMS protocol. This pain is usually described as sore, achy, tender, or annoying and may be similar to discomfort you experienced a few days after new or unfamiliar physical activity/exercise. There are also conditions that can arise from inducing DOMS. However, I will provide details about proper water consumption and provide a list of precautionary signs and symptoms following the DOMS session. I will also ask you questions prior to each treatment session to ensure that you are not having any health issues caused by the DOMS protocol.
2. The massage treatments used in this study can cause some mild side effects. First, you could feel some discomfort during each massage. Second, you may experience small marks over your bicep which look like bruising. The marks should not be uncomfortable and should disappear within 3 to 7 days after the final treatment. It is however, important that you understand that you can discontinue your participation at any time.
3. If your health status requires further medical consultation, I will refer you to the appropriate health care services. However, any costs for injuries or other medical attention are solely your responsibility.

Appendix A1. Informed Consent (Continued).

***Please be aware that** the treatments provided will be performed by a certified athletic trainer who has undergone specific training and earned a certification in the type of massage therapy included in this study. There is an emergency action plan in place in case of an emergency that includes the availability of emergency equipment such as an AED. Upon your completion in the study, I will explain some of the details about the study and provide you a list of precautionary signs/symptoms that could arise from DOMS induction. Be sure to remain properly hydrated throughout this study. (About half your body weight in ounces of water ever day)

Benefits and Compensation:
There will be no direct benefits or compensation that you will receive from participating in this research study.

Confidentiality:
Information obtained during this study, which could identify you, will be kept confidential. Only the principal investigator and committee chair will have access to the data to analyze the results. The summarized findings with no identifying information may be published in an academic journal or presented at a scholarly conference.

Right to Refuse or Withdraw:
You can choose whether or not to be in this study. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind or loss of benefits to which you are otherwise entitled. You may also refuse to answer any questions you do not want to answer. There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled.

The investigators may exclude you from this participation if it is determined that you can’t safely participate in this study or if your inclusion status changes during the study (e.g. Illness, begin additional weight lifting, taking pain medications, etc.)

Appendix A1. Informed Consent (Continued).

Questions:
If you have any questions or concerns about your rights as a research participant related to this study or the study itself, now or in the future, please contact:

Principle Investigator Carli V Mueller, LAT, ATC, CCT (certified cupping therapist) 003H HPC University of Northern Iowa (920) 627-4295 muellcak@uni.edu	Faculty Sponsors: Todd Evans, PhD, ATC, LAT todd.evans@uni.edu, 319-273-6152 Tricia Schrage, EeD, ATC, LAT Tricia.schrage@uni.edu, 319-273-7493 University of Northern Iowa OO3 HPC

Agreement: ***I am fully aware of the nature and extent of my participation in this project as stated above and the possible risks arising from it. I hereby agree to participate in this project. I acknowledge that I have received a copy of this consent statement. I am 18 years of age or older.***

____
(Signature of participant) (Date)

____
(Printed name of participant)

____
(Signature of investigator) (Date)

____
(Printed name of participant)

Appendix A2. Health History Questionnaire.

Subject Number: __________

Pre-Participation Health History Form
PLEASE DO NOT PUT YOUR NAME ON THIS PAPER

Ht. feet ___inches **Wt.** ___pounds **Age:_____** **Gender:** M F Transgender

1. Does the statement below best describe your physical activity level? **Yes** **No**
   I engage in moderate- intensity aerobic physical activity for a minimum of 30 minutes a day, 5 days a week or a vigorous intensity aerobic activity for a minimum of 20 minutes a day, 3 days a week.

2. Are you currently able to safely participate in intense exercise? **Yes** **No**

3. Are you currently participating in a weight-training program? **Yes** **No**

4. Do you incorporate bicep curls in your workout? **Yes** **No**
   4a. If so, how often do you bicep curl? ________________________
   4b. How much weight do you usually bicep curl?____________________
   4c. How many sets and reps do you usually perform with this weight?________
   4d. Do you usually do sets of bicep curls until failure? **Yes** **No**
   4e. If so, please explain how often? ____________________________

5. Do you have any known blood clotting disorder? **Yes** **No**

6. Have you ever had a reaction to silicone, oils, adhesive, nuts, grapes, or lotions?
   Yes **No**

7. Have you ever been diagnosed with any health related condition, illness, or disease that impacted your ability to safely exercise? **Yes** **No**

8. If yes, please explain: ______________________________________
   ____
   ____

9. Have you ever had severe adverse effects when weight lifting such as rhabdomyolysis or other adverse muscle responses? (More severe than soreness)

10. Have you ever been diagnosed with any serious musculoskeletal conditions or any of the following conditions: Malignancy, rhabdomyolysis, infection of the skin or

joint, tuberculosis, or a cardiac disease? **Yes** **No**

10a. If yes, please describe which condition and when you were diagnosed: ________

____

____

11. Have you ever had a serious injury to your non-dominant hand, wrist, forearm, elbow, upper arm, or shoulder? **Yes** **No**
    11a. If yes, please describe the injury and when it occurred: __________________

    ____

    ____

12. Have you had surgery in the past 6 months? **Yes** **No**
    12a. If so, what was the surgery for?_______________________________
    12b. When did you have the surgery?_______________________________

13. Are you currently undergoing rehabilitation for a previous injury? **Yes** **No**
    13a. If yes, what is the rehabilitation for? _________________________________

    ____

14. Do you currently have any other injury or condition that limits your activity level? **Yes** **No**
    14a. If so, which side is the other injury or condition located? **Right** **Left**
    14b. Please describe the injury or condition._______________________________

    ____

    ____

15. Do you currently have pain in your arms? **Yes** **No**
    15a. If yes, which arm is the pain located? **Right** **Left**
    15b. Where is the pain located in the arm? Be specific. ______________________

    ____

    ____

16. (Females) Is there a possibility you may be pregnant? **Yes** **No**

17. Are you currently sick? (flu, cold, upper respiratory infection, etc) **Yes** **No**

Appendix A2. Health History Questionnaire(Continued).

18. Do you currently have any open wounds, cuts, or infections on your arms?
    Yes **No**

19. Do you a history of any skin conditions that would interfere with a grapeseed oil application to your skin, and a massage? **Yes** **No**

20. Which hand do you write with? **Left** **Right**

If you answered "YES", to any questions, or you are unsure about any of your answers, you will be asked for more detail to help the researcher better assess whether your condition increases your risk for participation.

Appendix A3. Exit Interview.

Subject Number: __________

Exit Interview Questionnaire
PLEASE DO NOT PUT YOUR NAME ON THIS PAPER

1. Which day was your pain most severe?

Day1 Day2 Day3 Day4 Day5 Day6 Day 7

2. Did you feel the treatment was effective at managing your pain?

Yes No

3. Which day did you feel the most relief of pain from the treatment?

Session 2 Session3 Session4 Session5 Session6

4. Since the first session up to now, have you used any analgesics? (*Massage, apply ice, exercise, stretch, pain medication, or use any other modalities*)

Yes No

4a. If yes, please explain what you used.____
____

5. Since the first session up to now, have you participated in any form of physical activity? (*worked out, weight lifting, or cardio*)

Yes No

5a. If yes, please describe the physical activity you participated in. ___________________
____
____

Thank you for your participation. Your answers will be kept confidential. If you have any comments, questions, and/or concerns please address those with the primary researcher at this time. Thank you.

Appendix A4. Debriefing Form.

Debriefing Form

Thank you very much for your participation in my research.

Before you agreed to participate, I told you that my research was to investigate the differences between TWO different treatments for the pain associated with delayed onset muscle soreness (DOMS).

You were then randomly assigned to receive one of the two treatments.

If you did not complete all six session, it was because your pain was gone.

You received the ______________________treatment.

If you would like more information about my research, please contact me (muellcak@uni.edu; (920) 627-4295) my faculty advisor, Dr. Evans (319-273-6152; todd.evans@uni.edu), or the IRB Administrator, University of Northern Iowa, at 319-273-6148.

Thank you for your participation.

Carli Mueller, LAT, ATC, CCT
Principle Investigator
University of Northern Iowa
muellcak@uni.edu

Appendix A5. Pre-Treatment Symptom Checklist.

Subject Number:____________

Pre-Treatment Symptom Checklist
PLEASE DO NOT PUT YOUR NAME ON THIS PAPER

1. Does your urine appear to be darker/more red or brown than normal? **Yes** **No**

2. Do you feel like you have been urinating less frequently based on how much water you are consuming? **Yes** **No**

3. Have you felt extreme weakness in any of your extremities? **Yes** **No**

4. Have you experienced any abdominal pain? **Yes** **No**

5. Do you feel like you have a fever or increased heart rate? **Yes** **No**

6. Have you experienced any confusion, dizziness, or loss of consciousness? **Yes** **No**

7. Have you felt nauseous or vomited in the past 2 days? **Yes** **No**

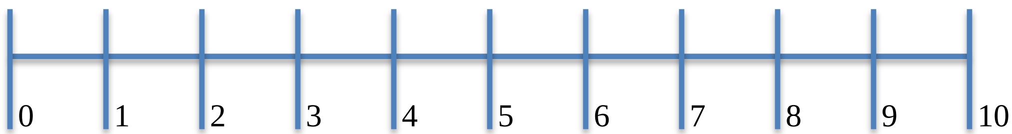
Appendix A6. Pre-Protocol Numerical Rating Scale Bilaterally .

Pre-Protocol Numerical Rating Scale, Bilaterally, 5 lb weight

Subject Number________

Please circle the number on the scale line that represents the intensity of the pain you experience at this moment.

Right Arm



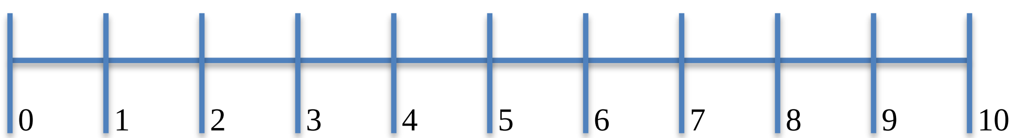
No Pain Worst Pain Possible

Pre-Protocol Numerical Rating Scale, Bilaterally, 5 lb weight

Subject Number________

Please circle the number on the scale line that represents the intensity of the pain you experience at this moment.

Left Arm



No Pain Worst Pain Possible

Appendix A7. DOMS Protocol.

DOMS Induction Protocol

1RM:_____________lb

Non-Dominant Arm: **Left** **Right**

Concentric Curls:

1RM-2.27 kg (5lbs)=________________

Reps in Set 1 to fatigue:____________________

30 second rest

Reps in set 2 to fatigue: _________________

Rest 1 minute

Eccentric Curls:

1RM+2.27 kg (5lbs)=________________

Set 1 (10 repetitions):

Weight:_______________ Reps:_________________

Weight:_______________ Reps:_________________

Weight:_______________ Reps:_________________

Rest 1 minute

Set 2 (10 repetitions):

Weight:_______________ Reps:_________________

Weight:_______________ Reps:_________________

Weight:________________ Reps:_________________

Appendix A7. DOMS Protocol (Continued).

Set 3 (10 repetitions):

Weight:________________ Reps:_________________

Weight:________________ Reps:_________________

Weight:________________ Reps:_________________

Rest 1 minute

Set 4 (10 repetitions):

Weight:________________ Reps:_________________

Weight:________________ Reps:_________________

Weight:________________ Reps:_________________

Rest 1 minute

Set 5 (10 repetitions):

Weight:________________ Reps:_________________

Weight:________________ Reps:_________________

Weight:________________ Reps:_________________

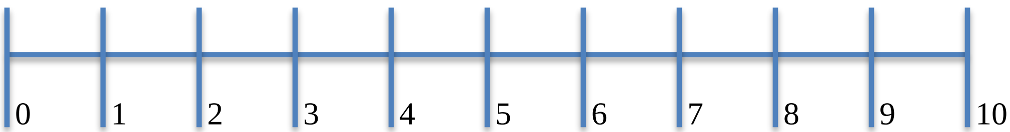
Appendix A8. Post-Protocol Numerical Rating Scale, Bilaterally.

Post-Protocol Numerical Rating Scale, Bilaterally

Subject Number________

Please circle the number on the scale line that represents the intensity of the pain you experience at this moment.

Right Arm



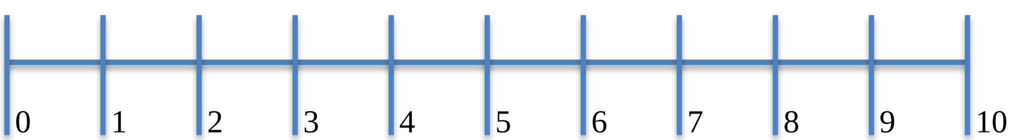
No Pain Worst Pain Possible

Post- Protocol Numerical Rating Scale, Bilaterally

Subject Number________

Please circle the number on the scale line that represents the intensity of the pain you experience at this moment.

Left Arm



No Pain Worst Pain Possible

Appendix A9. Pre-Treatment Numerical Rating Scale, Non-Dominant Arm.

Pre-Treatment Numerical Rating Scale, Non Dominant Arm, 5 lb weight

Subject Number________

Treatment Number_________

Please circle the number on the scale line that represents the intensity of the pain you experience at this moment.

Arm Tested: _________

0 1 2 3 4 5 6 7 8 9 10

No Pain Worst Pain Possible

Appendix A10. During Treatment Numerical Rating Scale, Non-Dominant Arm.

During Treatment Numerical Rating Scale, Non Dominant Arm

Subject Number________

Treatment Number_________

Please circle the number on the scale line that represents the intensity of the pain you experience at this moment.

Arm Tested: _________

0	1	2	3	4	5	6	7	8	9	10

No Pain Worst Pain Possible

Appendix A11. Post-Treatment Numerical Rating Scale, Non-Dominant Arm

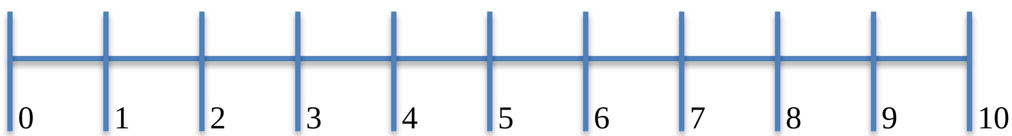
Post-Treatment Numerical Rating Scale, Non Dominant Arm, 5 lb weight

Subject Number________

Treatment Number_________

Please circle the number on the scale line that represents the intensity of the pain you experience at this moment.

Arm Tested: __________



No Pain Worst Pain Possible

APPENDIX B

ADDITIONAL MATERIAL

Appendix B1. Classroom Recruitment Script.

Recruitment Script

Script Classroom Recruiting
(*Instructors will not be present)

Hello Everyone,

For those that don't know me, my name is Carli Mueller. I'm a certified athletic trainer and a student in the athletic training master's program here at UNI and I am here to invite you to participate in my research study.

I am studying the effects of different treatments on pain; specifically, the effects of massage and cupping therapy pain relief. You might have seen this treatment being used already in the athletic training room.

If you participate in my study it will involve, 6 research sessions with me in the athletic training research lab (a minimum of 2, maximum of 6 sessions). The first session will include:

1. DOMS Induction (Day 1): If you meet the criteria, on the first day, probably a Sunday, I will ask you to complete a series of arm curls to the point of nearly exhausting your biceps. The purpose of these curls is to induce delayed onset muscle soreness; you've probably heard it called DOMS. This is what you feel a few days after you begin working out and you are very sore for the next several days. So if you participate, I will be asking you to give yourself DOMS to your biceps.
    a. You will be asked not to participate in any exercise including weight lifting and cardio activity during the duration of this study, approximately seven days. (Right now, I am only including those who are willing to NOT exercise for the duration of my study.)
    b. You will also be asked not to use any other pain-relieving techniques. This could include taking pain relieving medications such as ibuprofen or aspirin as well as applying hot or cold packs to the affected area for the duration of this study.
2. TREATMENTS (Days 3 – 6):
    a. Then, two days later, you will report back to the lab for your second session where you will receive one of two different treatments designed to relieve pain.
    b. Before, during, and after each treatment, I will ask you to rate and explain your level of pain in your biceps.
    c. You will be asked to report back the lab each day for a minimum of 3, maximum of 6 sessions, each session lasting for approximately a 1⁄2 hour each day, with the exception of the first session taking the longest, but no

more than 2 hours. *That means your maximum total time commitment for the study could be as long 4.5 hours over a maximum of 6 days.

If you are interested in participating, please write your name, email address, and phone number on the piece of paper you received. (**If you WOULD participate but you do NOT want to give up exercise, there will be a box for you to check.) Then I will contact you to answer your questions, ask you a few inclusion questions (e.g. how often do you perform curls? Have you ever had a really “bad" DOMS experience? Etc.), and then set up your first session if you meet all of my inclusion criteria.

If you are not interested in participating, just leave the piece of paper blank and I will still collect them all together.

Thank you very much for your time. Have a great day!

REFERENCES

Akbarzade, M., Ghaemmaghami, M., Yazdanpanahi, Z., Zare, N., Mohagheghzadeh, A., & Azizi, A. (2016). Comparison of the Effect of Dry Cupping Therapy and Acupressure at BL23 Point on Intensity of Postpartum Perineal Pain on the Short FOrm of McGill Pain Questionnaire. *Journal of Reproduction & Infertility*, *17*(1), 39–46.

Akbarzadeh, M., Ghaemmaghami, M., Yazdanpanahi, Z., Zare, N., Azizi, A., & Mohagheghzadeh, A. (2014). The Effect of Dry Cupping Therapy at Acupoing BL23 on the Intensity of Postpartum Low Back Pain in Primiparous Women Based on Two Types of Questionnaires, 2012; A Randomized Clinical Trial. *International Journal of Community Based Nursing and Midwifery*, *2*(2), 112–120.

AlBedah, A., Khalil, M., Elolemy, A., Hussein, A. a, AlQaed, M., Al Mudaiheem, A., … Bakrain, M. Y. (2015). The Use of Wet Cupping for Persistent Nonspecific Low Back Pain: Randomized Controlled Clinical Trial. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, *21*(8), 504–508. https://doi.org/10.1089/acm.2015.0065

Allen, J. D., Mattacola, C. G., & Perrin, D. H. (1999). Effect of Microcurrent Stimulation on Delayed-Onset Muscle Soreness: A Double-Blind Comparison. *Journal of Athletic Training*, *34*(4), 334–337.

Bakhtiary, A. H., Safavi-Farokhi, Z., & Aminian-Far, A. (2007). Influence of vibration on delayed onset of muscle soreness following eccentric exercise. *British Journal of Sports Medicine*, *41*(3), 145–148. https://doi.org/10.1136/bjsm.2006.031278

Bijur, P. E., Latimer, C. T., & Gallagher, E. J. (2003). Validation of a verbally administered mumerical rating scale of acute pain for use in the emergency department. *Academic Emergency Medicine*, *10*(4), 390–392. https://doi.org/10.1111/j.1553-2712.2003.tb01355.x

Bijur, P., Silver, W., & Gallagher, E. (2001). Reliability of the visual analog scale for measurement of acute pain. *Academic Emergency Medicine*, *8*(12), 1153–1157. https://doi.org/10.1111/j.1553-2712.2001.tb01132.x

Brownson, R. C., & Petitti, D. B. (1998). *Applied Epidemiology*. New York, New York: Oxford University Press, Inc.

Butterfield, D. L., Draper, D. O., Ricard, M. D., Myrer, J. W., Durrant, E., & Schulthies, S. S. (1997). The effects of high-volt pulsed current electrical stimulation on delayed-onset muscle soreness. *Journal of Athletic Training*, *32*(1), 15–20.

Cheung, K., Hume, P. A., & Maxwell, L. (2003). Treatment Strategies and Performance Factors, *33*(2), 145–164.

Chi, L.-M., Lin, L.-M., Chen, C.-L., Wang, S.-F., Lai, H.-L., & Peng, T.-C. (2016). The effectiveness of cupping therapy on relieving chronic neck and shoulder pain: A randomized controlled trial. *Evidence-Based Complementary and Alternative Medicine : ECAM*, *2016*(1), 7358918. https://doi.org/10.1155/2016/7358918

Clancy, C. M., & Eisenberg, J. M. (1998). Outcomes research: Measuring the end result of health care. *American Association for the Advancement of Science*, 245–248.

Clarkson, P. M., & Tremblay, I. (1988). Exercise-induced muscle damage, repair and adaptations in humans. *American Physiological Society*, *88*, 1–6.

Cormack, J. C. (2002). Evidence-Based Practice...What Is IT and How Do I Do It? *Journal of Orthopedic & Sports Physical Therapy*, *32*(10), 484–487.

Cramer, H., Lauche, R., Hohmann, C., Choi, K. E., Rampp, T., Musial, F., … Dobos, G. (2011). Randomized controlled trial of pulsating cupping (pneumatic pulsation therapy) for chronic neck pain. *Forschende Komplementarmedizin*, *18*(6), 327–334. https://doi.org/10.1159/000335294

Donabedian, A. (1988). Quality assessment and assurance: Unity of purpose, diversity of means. *Inquiry*, *25*(1), 173–192.

Donnelly, A. E., Maughan, R. J., & Whiting, P. H. (1990). Effects of ibuprofen on exercise-induced muscle soreness and indices of muscle damage. *British Journal of Sports Medicine*, *24*(3), 191–195. https://doi.org/10.1136/bjsm.24.3.191

Donnelly, A., McCormick, K., Maughan, R., Whiting, P., & Clarkson, P. (1988). Effects of a non-steroidal anti-inflammatory drug on delayed onset muscle soreness and indices of muscle damage. *British Journal of Sports Medicine*, *22*(1), 35–38.

Evans, T. A., & Lam, K. C. (2011). Clinical Outcomes Assessment in Sport Rehabilitation. *Journal of Sport Rehabilitation*, *20*, 8–16.

Farhadi, K., Schwebel, D. C., Saeb, M., Choubsaz, M., Mohammadi, R., & Ahmadi, A. (2009). The effectiveness of wet-cupping for nonspecific low back pain in Iran: A randomized controlled trial. *Complementary Therapies in Medicine*, *17*(1), 9–15. https://doi.org/10.1016/j.ctim.2008.05.003

Farr, T., Nottle, C., Nosaka, K., Sacco, P. (2002). Theeffects of therapeutic massage on delayed onset muscle soreness and muscle function following downhill walking. *Journal of Science and Medicine and Sport*, *5*, 297–306.

Fonda, B., & Sarabon, N. (2013). Effects of whole-body cryotherapy on recovery after hamstring damaging exercise: A crossover study. *Scandinavian Journal of Medicine and Science in Sports*, *23*(5), 270–278. https://doi.org/10.1111/sms.12074

Frey Law, L. A., Evans, S., Knudtson, J., Nus, S., Scholl, K., & Sluka, K. A. (2008). Massage Reduces Pain Perception and Hyperalgesia in Experimental Muscle Pain: A Randomized, Controlled Trial. *Journal of Pain*, *9*(8), 714–721. https://doi.org/10.1016/j.jpain.2008.03.009

Ge, W., Leson, C., & Vukovic, C. (2017). Dry Cupping for Plantar Fasciitis: a Randomized Controlled Trial. *The Journal of Physical Therapy*, *29*, 859–862.

Grossman, J. M., Arnold, B. L., Perrin, D. H., & Kahler, D. M. (1995). Effect of Ibuprofen Use on Delayed Onset Muscle Soreness of the Elbow Flexors. *Journal of Sport Rehabilitation*, *4*, 253–263. https://doi.org/10.1123/jsr.4.4.253

Gulick, D. T., & Kimura, I. F. (1996). Delayed onset muscle soreness: What is it and how do we treat it? *Journal of Sport Rehabilitation*, *5*, 234–243.

Haensel, L., Mithoefer, K., Ekstrand, J., English, B., Mcnally, S., Orchard, J., … Ueblacker, P. (2012). Terminology and classification of muscle injuries in sport : A consensus statement, *0*, 1–9. https://doi.org/10.1136/bjsports-2012-091448

Haynes, B. R. (2002). Physicians' and patients' choices in evidence based practice: evidence does not make decisions, people do. *British Medical Journal*, 1350. Retrieved from http://discovery.ucl.ac.uk/1315238/

Hilbert, J. E., Sforzo, G. A., & Swensen, T. (2003). The effects of massage on delayed onset muscle soreness. *British Journal of Sports Medicine*, *37*(1), 72–75. https://doi.org/10.1136/bjsm.37.1.72

Hong, Z. (2000). Cervical Spondylosis: 100 Patients Treated with Sliding Cupping. *Journal of Chinese Medicine2*, 40–41.

Hong, Z. (2001). The Clinical Application of Sliding Cupping. *Journal of Chinese Medicine*, 38–39.

Isabell, W. K., Durrant, E., Myrer, W., & Anderson, S. (1992). The effects of ice massage, ice massage with exercise, and exercise on the prevention and treatment of delayed onset muscle soreness. *Journal of Athletic Training*, *27*(3), 208–217. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1317248&tool=pmcentrez&rendertype=abstract

Jakeman, J., Byrne, C., Eston, R. (2010). Efficacy of lower limb compression and combined treatment of manual massage and lower limb compression on symptoms of exercise induced muscle damage in women. *Journal of Strength and Conditioning Research*, *24*(11), 3157–3165.

Kim, J.-I., Kim, T.-H., Lee, M. S., Kang, J. W., Kim, K. H., Choi, J.-Y., … Choi, S. (2011). Evaluation of wet-cupping therapy for persistent non-specific low back pain: a randomised, waiting-list controlled, open-label, parallel-group pilot trial. *Trials*, *12*, 146. https://doi.org/10.1186/1745-6215-12-146

Kuehl, K. S., Perrier, E. T., Elliot, D. L., & Chesnutt, J. C. (2010). Efficacy of tart cherry juice in reducing muscle pain during running: a randomized controlled trial. *Journal of the International Society of Sports Nutrition*, *7*, 17. https://doi.org/10.1186/1550-2783-7-17

Kuligouski, L. A., Lephart, S. M., Gianantonio, F. P., & Blanc, R. O. (1998). Effect of whirlpool therapy on the signs and symptoms of delayed-onset muscle sorness. *Journal of Athletic Training*, *33*(3), 222–228.

Lau, W. Y., Blazevich, A. J., Newton, M. J., Xuan Wu, S. S., & Nosaka, K. (2015). Assessment of muscle pain induced by elbow-flexor eccentric exercise. *Journal of Athletic Training*, *50*(11), 1140–1148. https://doi.org/10.4085/1062-6050-50.11.05

Lauche, R., Cramer, H., Choi, K.-E., Rampp, T., Saha, F. J., Dobos, G. J., & Musial, F. (2011). The influence of a series of five dry cupping treatments on pain and mechanical thresholds in patients with chronic non-specific neck pain -a randomized controlled pilot study. *BMC Complementary and Alternative Medicine*, *11*(63), 1–11. https://doi.org/10.1186/1472-6882-11-63

Lauche, R., Cramer, H., Hohmann, C., Choi, K. E., Rampp, T., Saha, F. J., … Dobos, G. (2012). The effect of traditional cupping on pain and mechanical thresholds in patients with chronic nonspecific neck pain: A randomised controlled pilot study. *Evidence-Based Complementary and Alternative Medicine*, *2012*. https://doi.org/10.1155/2012/429718

Lauche, R., Materdey, S., Cramer, H., Haller, H., Stange, R., Dobos, G., & Rampp, T. (2013). Effectiveness of home-based cupping massage compared to progressive muscle relaxation in patients with chronic neck pain-A randomized controlled trial. *PLoS ONE*, *8*(6). https://doi.org/10.1371/journal.pone.0065378

Lauche, R., Spitzer, J., Schwahn, B., Ostermann, T., Bernardy, K., Cramer, H., … Langhorst, J. (2016). Efficacy of Cupping Therapy in Patients with the Fibromyalgia Syndrome- a randomized placebo controlled trial. *Scientific Reports*, *6*(37316), 1–10.

Lee, M. S., Kim, J.-I., Kong, J. C., Lee, D.-H., & Shin, B.-C. (2010). Developing and Validating a Sham Cupping Device. *Accupuncture Medicine*, *28*, 200–204.

Malik, I. A., Akhter, S., & Kamal, M. A. (2015). Treatment of psoriasis by using Hijamah: A case report. *Saudi Journal of Biological Sciences*, *22*(1), 117–121. https://doi.org/10.1016/j.sjbs.2014.09.004

Mancinelli, C. A., Davis, D. S., Aboulhosn, L., Brady, M., Eisenhofer, J., & Foutty, S. (2006). The effects of massage on delayed onset muscle soreness and physical performance in female collegiate athletes. *Physical Therapy in Sport*, *7*(1), 5–13. https://doi.org/10.1016/j.ptsp.2005.10.004

Markowski, A., Sanford, S., Pikowski, J., Fauvell, D., Cimino, D., & Caplan, S. (2014). A pilot study analyzing the effects of Chinese cupping as an adjunct treatment for patients with subacute low back pain on relieving pain, improving range of motion, and improving function. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, *20*(2), 113–117. https://doi.org/10.1089/acm.2012.0769

Michalsen, A., Bock, S., Lüdtke, R., Rampp, T., Baecker, M., Bachmann, J., … Dobos, G. J. (2009). Effects of traditional cupping therapy in patients with carpal tunnel syndrome: A randomized controlled trial. *The Journal of Pain*, *10*(6), 601–608. https://doi.org/10.1016/j.jpain.2008.12.013

Micklewright, D. (2009). The effect of soft tissue release on delayed onset muscle soreness: a pilot study. *Physical Therapy in Sport*, *10*(1), 19–24.

Minder, P. M., Noble, J. G., Alves-Guerreiro, J., Hill, I. D., Lowe, A. S., Walsh, D. M., & Baxter, G. D. (2002). Interferential therapy: Lack of effect upon experimentally induced delayed onset muscle soreness. *Clinical Physiology and Functional Imaging*, *22*(5), 339–347. https://doi.org/10.1046/j.1475-097X.2002.00441.x

Ogai, R., Yamane, M., Matsumoto, T., & Kosaka, M. (2008). Effects of petrissage massage on fatigue and exercise performance following intensive cycle pedalling. *British Journal of Sports Medicine*, *42*(10), 834–838. https://doi.org/10.1136/bjsm.2007.044396

Petrofsky, J., Berk, L., Bains, G., Khowailed, I. A., Hui, T., Granado, M., … Lee, H. (2013). Moist heat or dry heat for delayed onset muscle soreness. *Journal of Clinical Medicine Research*, *5*(6), 416–425. https://doi.org/10.4021/jocmr1521w

Price, D. D., McGrath, P. A., Rafii, A., & Buckingham, B. (1983). The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. *Pain*, *17*(1), 45–56. https://doi.org/10.1016/0304-3959(83)90126-4

Rodenburg, J., Steenbeek, D., Bar, P. (1994). Warm-up, stretching and massage diminish harmful effects of eccentric exercise. *International Journal of Sports Medicine, 15*(7), 414–419.

Sackett, D., Rosenberg, W., Gray, J., Haynes, R., & Richardson, W. (1996). Evidence based medicine: What it is and what it isn't - It's about integrating individual clinical expertise and the best external evidence. *British Medical Journal*, *312*(1), 71–72. https://doi.org/10.2307/29730277

Sargent, D. (2010). What Constitutes Reasonable Evidence of Efficacy and Effectiveness to Guide Oncology Treatment Decisions? *The Oncologist*, *15*(Supplement 1), 19–23. https://doi.org/10.1634/theoncologist.2010-S1-19

Schoulz, J., Snyder, K., Evans, T., Lund, R. (2014). Effect of Soft Tissue Oscillation Therapy on the Relief of Pain Associated With Delayed Onset Muscle Soreness. *Athletic Training & Sports Health Care: The Journal for the Practicing Clinician, 9*(1), 17-23.

Smith, L., Keating, M., Holbert, D., Spratt, D., McCammon, M. (1994). The effects of athletic massage on delayed onset muscle soreness, creatine kinase, and neutrophil count: a preliminary report. *Journal of Orthopedic & Sports Physical Therapy*, *19,* 93–99.

Straus, S. E., & Sackett, D. L. (1998). Review on evidence-based cancer medicine: Applying evidence to the individual patient. *Bmj*, *317*(Table 1), 339–342. Retrieved from http://www.hubmed.org/display.cgi?uids=10076718%5Cn$%5C$$%5C$gbkenpfsphg0001$%5C$Resolute$%5C$DATA$%5C$PurpleHat$%5C$clients.ph$%5C$MerckSerono$%5C$Admin$%5C$References$%5CCRC%5C$Straus%7B_%7DAnn%5CnOncol%7B_%7D1999%7B_%7Devidence-based%5Cncancer%5Cnmed

Svensson, P., Minoshima, S., Beydoun, a, Morrow, T. J., & Casey, K. L. (1997). Cerebral processing of acute skin and muscle pain in humans. *Journal of Neurophysiology*, *78*, 450–460.

Teut, M., Kaiser, S., Ortiz, M., Roll, S., Binting, S., Willich, S. N., & Brinkhaus, B. (2012). Pulsatile dry cupping in patients with osteoarthritis of the knee - a randomized controlled exploratory trial. *BMC Complementary and Alternative Medicine*, *12*(1), 184. https://doi.org/10.1186/1472-6882-12-184

Ullah, K., Younis, A., Wali, M. (2007). An investigation into the effect of Cupping Therapy as a treatment for Anterior Knee Pain and its potential role in Health Promotion. *The Internet Journal of Alternative Medicine, 4*(1), 1. https://doi.org/10.5580/796

Valovich McLeod, T. C., Snyder, A. R., Parsons, J. T., Bay, C., Michener, L. A., & Sauers, E. L. (2008). Using disablement models and clinical outcomes assessment to enable evidence-based practice, part II: Clinical outcomes assessment. *Journal of Athletic Training*, *43*(4), 437–445.

Weber, M. D., Servedio, F. J., & Woodall, W. R. (1994). The effects of three modalities on delayed onset muscle soreness. *J Orthop Sports Phys Ther*, *20*(5), 236–242. https://doi.org/10.2519/jospt.1994.20.5.236

Wenos, J., Brilla, L., Morrison, M. (1990). Effect of massage on delayed onset muscle soreness. *Medicine and Science in Sports and Exercise*, *22*, S34.

Zainuddin, Z., Newton, M., Sacco, P., & Nosaka, K. (2005). The effects of massage on delayed onset muscle soreness. *Journal of Athletic Training*, *40*(3), 174–180. https://doi.org/10.1136/bjsm.37.1.72