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The Acute Effects of Cupping Therapy on Hamstring Range of Motion Compared to Sham

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THE ACUTE EFFECTS OF CUPPING THERAPY ON HAMSTRING RANGE OF MOTION COMPARED TO SHAM.

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ABSTRACT

The Acute Effects of Cupping Therapy on Hamstring Range of Motion Compared to Sham

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Context: Flexibility is an important aspect of physical performance and when deficient can result in an increased opportunity for injury. Cupping therapy is an ancient technique that has recently seen a growth in popularity in Western Orthopedic medicine as a soft tissue mobilization technique. Most cupping therapy research explores the use of cupping therapy for treating headache, herpes zoster, asthma, cough, and other non-orthopedic pathologies. Cupping therapy has had positive results on an injured population for increasing flexibility. **Objective:** To identify if cupping therapy applied passively for 10 minutes results in an increase in flexibility, and to identify if there is a placebo effect with the sham cupping treatment. **Design:** Double-blinded randomized repeated measures trial. **Setting:** laboratory. **Participants:** 40 semi-active participants were recruited (age: 23.52 ± 3.50 years, height: 171.89 ± 9.23 cm, mass: 72.864 ± 14.90 kg) with hamstring range of motion less than 80 degrees. Exclusion criteria included previous cupping therapy experience, allergies to adhesive, any lower extremity injury in the past 6 months, previous cupping experience and cupping therapy contraindications: pregnancy, sunburn, rash, contusions. **Methods:** Participants reported to the Sports Injury Research Clinic on three occasions, on the first occasion participants completed informed consent and questionnaire, followed by the secondary investigator performing the pre-treatment measurement, then the primary investigator performed one of three randomly assigned treatment options, cupping, sham, and control. Treatment was for 10 minutes with the patient laying prone and relaxed. Then the participant underwent range of motion testing post treatment, and after 10 minutes of laying relaxed. Participants returned on two other occasions with at least one week in between to perform the other treatment conditions. **Main Outcome Measurements:** Hamstring range of motion to measure flexibility, measured three times, pre-treatment, post-treatment, and 10 minutes post-treatment. An active straight leg raise was performed 4 times for each measurement with the average of the last 2 was taken as the measurement. A 3x3x2 ANOVA in SPSS was utilized for data analysis. **Results:** There was no statistically significant difference between cupping and control conditions (p=0.004). Cupping had a significantly higher range of motion at pre-treatment (p=0.032), post-treatment (p=0.017), and 10-minutes (p=0.006). There was no significant difference in the interaction between Condition, Time, and Sex (p=0.263). There was no significant interaction between Condition and Sex (p=0.230), Time and Condition (p=0.443), and Time and Sex (p=0.064). **Conclusion:** Cupping therapy applied to a healthy individual for 10 minutes does not create an increase in hamstring flexibility. **Word Count:** 410 words

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Chapter 1: Introduction

Flexibility is the total movement around a joint and deficient flexibility can lead to an increase chance of injury.[1, 2] Decreases in hamstring flexibility can lead to low back pain,[3, 4], asymmetrical lower body musculature,[1, 5, 6] asymmetrical lower body activation,[7, 8] and predispose the individual to further injuries.[9] Decreased hamstring flexibility can also cause decreased pelvic mobility.[5] Decreased pelvic mobility has been previously associated with hamstring strains,[10] thoracic hyperkyphosis,[6] disc herniation,[11] spondylolysis,[12] and low back pain.[3, 4] Injuries associated with decreased flexibility may be prevented with flexibility programs that include stretching and soft tissue mobilization.[10, 13] Massage and instrument-assisted soft tissue mobilization are popular soft tissue mobilization techniques, however in the past decade cupping therapy has started to gain popularity in Western medicine.[14]

Cupping therapy has been used as a medical technique with accounts from Asia, Egypt, the Middle East, and Eastern Europe dating back to 1550 BCE.[15] After falling out of favor in Western medicine in the 20th century, cupping therapy has seen a recent resurgence for soft tissue mobilization.[14] Cupping therapy uses glass or plastic cups, along with fire or a vacuum pump, to create a negative pressure on the body. The negative pressure is proposed to cause a vast array of physiological changes including: increasing blood circulation,[16] alleviating pain,[17,18] reducing swelling,[18] regulating body temperature,[16] increasing skin temperature,[19] decreasing blood pressure,[19] irritating the immune system causing local inflammation,[20] and improve neurophysiological performance.[21] Cupping therapy has a simple application with minimal risk of adverse reactions, and can result in decreased musculature pain and tenderness.[22]

Most of the current cupping therapy research has been produced in China, where cupping is used to treat a variety of pathologies.[23-25] A systematic review from China reported that cupping therapy can be utilized as a treatment option for a wide variety of conditions, including pain conditions, cough, asthma, acne, cervical spondylosis, and herpes zoster.[23] Conversely, systematic reviews have noted that randomized controlled trials of cupping therapy with more rigorous methodological quality are needed.[23-25] The limited current orthopedic research has found cupping therapy to have a beneficial effect on flexibility on injured participants.[17, 26] However, neither orthopedic study employed a blinding process, a sham, or a control condition, leading to possible biases and placebo effect to occur in this patient population.[17, 26] In addition, current literature has not evaluated cupping therapy's use prophylactically in healthy populations to increase range of motion (ROM).

Therefore, the purpose of this study was to evaluate the effectiveness of cupping therapy on hamstring flexibility in healthy adults, when compared to a sham treatment and control. We hypothesized that the application of cupping therapy would result in a significant increase in hamstring flexibility, as measured via hip flexion ROM, when compared to both the sham cupping technique and controls.

CHAPTER 2: REVIEW OF LITERATURE

Cupping therapy has been used as a technique in Eastern medicine with written accounts dating as far back as 1550 BCE.[15] Cupping therapy has seen a recent resurgence in Western medicine more currently as a soft tissue mobilization technique.[16] To this end, this review of literature will focus on the following topics: connective tissue, flexibility, soft tissue mobilization techniques, and ROM measurement instruments.

Connective Tissue

The fascia is the largest organ of the human body, and is involved in every bodily system.[27] Soft tissue mobilization acts upon the fascia with the intent to correct any complications that can restrict the fascia and reduce performance. The fascia surrounds every nerve, vein, artery, muscle, and organ.[27] An important function of the fascia is the movement of the musculoskeletal system by transmitting the mechanical forces of the muscles.[27] The fascia also hosts fibroblasts which aid in wound healing.[27] There are two main portions to the fascia: superficial and deep.[28]

The superficial fascia surrounds and supports the veins and nerves.[29] A significant amount of free nerve endings are housed in the superficial fascia including nociceptive fibers which are responsible for pain perception.[29] The mobility of the superficial fascia prevents damage to the skin, veins, nerves, and underlying structures during physical motion.[28] If the superficial fascia is restricted the free nerves endings can become irritated causing chronic pain.[29]

The deep fascia surrounds muscles and shares muscle spindles.[28-30] Muscle spindles communicate with the central nervous system about muscle tone, movement, position, loss of normal elasticity, absolute length of the muscle, and the rate of change the muscle is undergoing.[30] Because the deep fascia contains a portion of the muscles spindles, the deep fascia plays an important role in proprioception.[29, 30] Not all muscles fibers enact their force on the myotendinous junction with 30%-40% of the force generated by muscles acting on the deep fascia.[30]

The fascia is composed of ground substance and the elastocollagenous complex.[31] The fascia's elastocollagenous complex is composed of elastin fibers, collagen fibers and reticulin fibers. Elastin is a protein that is found in the skin and gives skin the ability to stretch and return to original shape.[31] Collagen found in fascia is irregularly arranged fibers which creates the fascia's ability to resist tensional forces from multiple directions and fill the role as a packing tissue.[32] Collagen creates the tension resistance and stretch in the deep fascia, ligaments, and tendons.[31]

Tensegrity, or tension integrity, refers to the fascia's ability to yield and yet not break.[32] Tensegrity applies to cells because of their ability to resist distorting their shape and their ability to self-stabilize.[33] There are two ways that the fascia provides support within the body, either through compression or through tension.[32, 33] Tensegrity keeps a balanced order between the compressive and tensile forces created during movement to maintain stability within the human body.[32,33]

Fascial meridians are an important concept within tensegrity that are utilized in traditional Chinese medicine.[33,34] These meridians are utilized when representing how an increase in tension at one section can cause tension at another site, for example it is proposed that plantar fasciitis can affect the fascia surrounding the hip.[32] Fascial meridians explain how a myofascial adhesion at one point in the body not only affects the muscle at the location but will cause other muscles to compensate thus affecting those muscles. One Chinese project used magnetic resonance imaging and computed tomography to create a fascial image of the human body and found line-like structures in an almost replicated pattern as the traditional Chinese meridians.[33, 34]

The fascia encompasses every bodily system by surrounding every nerve, vein, artery, muscle, and organ.[27] In addition to protecting, the fascia receives part of the mechanical forces of the muscles, and has the pliability that allows for stretching.[27, 31] Through the concept of fascial meridians, any restrictions or adhesions at one point can further affect multiple points of the fascia and the muscles that the fasica acts upon.[31] Therefore, maintaining the fascia health and mobility is theorized to be crucial for performance.

Flexibility in Relation to Injury Prevention

Flexibility is the absolute ROM at a joint.[2] Flexibility is an important aspect of physical performance and can be attained and maintained through the use of stretching programs.[10,13] However, in individuals that are hyper-flexible, increasing flexibility may have negative effects including joint and musculoskeletal pain.[35]

Decreased flexibility, particularly in the hamstrings, can lead to further musculoskeletal injuries.[1, 3, 4, 7-9] Individuals with decreased hamstring flexibility can present with gait limitations, and an increased risk of falls.[9] Also, a decreased hamstring flexibility predisposes individuals to thoracic hyperkyphosis,[6] disc herniation,[11] spondylolysis,[12] and low back pain.[3, 4] Hamstring injuries are the most prevalent lower extremity musculotendinous injuries.[10] In football, 41% of all injuries are hamstring muscle injuries.[13] Also hamstring re-injury for quick start and stop sport athletes in the same season is 34%.[13] One study focused on a football team that found a 48.8% decrease in soft tissue injury rates following the implementation of a year-long stretching program (1994=43 musculotendinous injuries, 1995=21 musculotendinous injuries).[10] These results do not prove that stretching was the only cause for the decrease in injury rates, however it can be hypothesized that the stretching program aided in the decrease of observed injuries.[10]

The hamstrings are the most injured muscles in the lower extremity, and can contribute to low back pain and other pathologies if left untreated.[3, 4, 10] Increasing hamstring flexibility can help to decrease the risk of injuries.[1, 3, 7-9] Therefore individuals participating in physical activity should strive to maintain adequate flexibility through stretching programs or other methods of increasing flexibility.

Soft Tissue Mobilization

Soft tissue mobilization is one possible method for increasing flexibility in patients.[17, 26, 36-38] Cupping therapy, instrument assisted soft tissue mobilization, and self-myofascial release are three popular mobilization techniques employed by clinicians to increase flexibility. The following studies will explore the use of cupping therapy, instrument-assisted soft tissue mobilization, and self-myofascial release on improving flexibility.

Cupping Therapy

Since cupping therapy's return to Western orthopedic practice, there have been two studies evaluating the flexibility benefits. Markowski et al.[17] conducted a pilot study exploring the physiological benefits of a single bout of cupping therapy treatment on the lower erector spinae that resulted in a decrease in low back pain (p=0.0001), a statistically significant increase in hamstring straight leg raise ROM (p=0.043) and significant increase in lumbar flexion (p=0.016). Participants had two cups placed along each side of the lumbar spine for 10 minutes while laying passively prone.[17] In the second flexibility study, Lacross et al.[26] utilized a type of cupping therapy that incorporates movement on student athletes that had hamstring pathologies. The participants first received light instrument assisted soft tissue mobilization then had six cups placed along the hamstring (three medial, three lateral).[26] For the movement, participants were instructed to perform prone hamstring curls, and then through passive ROM with the cups in place. The alternative treatment group had 10-minutes of moist heat pack application, followed by three minutes of self-myofascial release.[26] Lacross's myofascial decompression treatment resulted in an average four degrees increase in passive straight leg raise ROM a significant increase.[26] The self-myofascial release group also had a significant increase, and the post treatment increase of myofascial decompression was significant compared to the self-myofascial release.[26]

Instrument-Assisted Soft Tissue Mobilization

Two instrument-assisted soft tissue mobilization studies evaluated the use of Graston Technique® for increasing flexibility with injured participants. Moon et al.[36] utilized 60 seconds of Graston Technique® and 1-minute of static stretching for chronic low back pain participants on the lumbar erector spinae. Using a sit and reach test, investigators found both groups had a significant increase in flexibility from pre to post treatment ($p=0.002$) and that the Graston Technique® group had an additional significant increase over the static stretching group ($p=0.002$).[36] In a 4-week intervention study, Lee et al.[37] recruited chronic low back pain participants, and placed them in either a 40-second Graston Technique® group or a 10-15 minutes bike control group. Using a phone digital inclinometer application, Lee found both groups had in increase in lumbar flexion (Graston $p<0.001$, Bike $p=0.492$), lumbar extension (Graston $p<0.001$, Bike $p=0.026$), lateral bending to the right (Graston $p<0.001$, Bike $p=0.002$), lateral bending to the left (Graston $p<0.001$, Bike $p=0.014$), and hip flexion (Graston $p<0.001$, Bike $p=0.21$).[37] Lee also noted a significant difference between the Graston Technique® and bike groups but did not report a significance level for it.[37]

Self-Myofascial Release

In a flexibility study investigating different durations of self-myofascial release, Kipnis et al.[38] recruited healthy individuals for a two-day study where the first day participants were randomly assigned to three groups: 30-seconds foam rolling, 2-minutes foam rolling, and a control group. On the second day, participants had a baseline flexibility measurement taken, walked on a treadmill for 5-minutes, had flexibility measured again, performed foam rolling for the designated amount of time, and a final flexibility measurement.[38] Kipnis et al.[38] found that all groups had a significant increase in hamstring flexibility measurements from baseline to post-treadmill ($p=0.001$), and there was no significant difference between post-treadmill, and post-foam rolling measurements ($P=1.00$).

Cupping therapy, instrument-assisted soft tissue mobilization, and self-myofascial release have been utilized to increase flexibility by clinicians and researchers.[17, 26, 36-38] All of the soft tissue mobilization methods have found significant increases to flexibility after application.[17, 26, 36-38] Currently, cupping therapy has the least amount of orthopedic studies published about the possible musculoskeletal benefits.

Measurement Methods

There are several methods to measure the ROM at a joint with positives and negatives to using each of them. The most popular ROM measurement methods are goniometers, tape measures of a specific task, bubble inclinometers, and digital inclinometers.

The goniometer in an inexpensive instrument that is easily used in the clinical setting, although the goniometer requires some technical skill by the user to find the three body landmarks for the axis and fulcrum, and consistently use the same point each reading.[39] This technical skill makes for the goniometer to have a lower reliability values (ICC= 0.65-0.89).[39, 40] Goniometers also require the use of both hands on the instrument making for a lack of stabilizing hand on the participant increasing the chance of error and excess motion.[40, 41]

The inclinometer uses either a bubble, dial, or digital reader, and only requires one body landmark to be used.[39] The digital inclinometer is advantageous because the instrument gives a single number reading instead of having the tester read the bubble or dial.[39] The digital inclinometer has a higher reliability values (ICC= 0.84-0.95).[39-41] Apart from being more expensive, the digital inclinometer also has to consistently have a zero point taken to reduce errors.[41] The digital inclinometer has also been found to have a higher sensitivity to the changes in motion than the goniometer does.[39] In one study of ankle dorsiflexion measurement with novice testers using goniometer, digital inclinometer, and a tape measure method, each yielded reliable results with the digital inclinometer and tape measure having the highest reliability and lowest error.[39] The tape measure method was used with weight bearing dorsiflexion by having the patient step on a tape measure (10 cm from a wall) lunge toward the wall having the knee touch the wall then sliding the foot back until the knee is just barely in contact with the wall.[39] Of the studies found, two in particular note caution if both goniometer and digital inclinometer are used as one found a statistical significance difference between the two, and both suggest utilizing one method for studies.[40, 41]

All of the ROM methods have merit but the digital inclinometer has the highest reliability and sensitivity for measuring ROM.[39-41] Therefore a digital inclinometer was utilized in the current study to obtain all ROM measurements.

Conclusion

Maintaining a healthy flexibility is an important aspect to the prevention of athletic injuries.[1, 10] Because decreased hamstring flexibility increases the risk of common chronic injuries,[1, 3, 4] it is important to explore the effectiveness of soft tissue mobilization techniques to increase flexibility. Instrument assisted soft tissue mobilization, and self-myofascial release have been shown in multiple studies to increase flexibility after treatment.[17, 26, 36-38] Cupping therapy has become an increasingly popular soft tissue mobilization in orthopedics although there are few studies exploring the orthopedic benefits and no studies that demonstrate any placebo effects.[17, 26] Therefore, the purpose of this thesis is to evaluate the effectiveness of cupping therapy on hamstring flexibility when compared to a sham treatment and control.

CHAPTER 3: METHODS

Research Design

A double-blinded repeated measures randomized control trial was conducted to evaluate the effectiveness of cupping therapy on hamstring flexibility. The independent variables were treatment conditions, time, and sex. The dependent variable was hamstring flexibility, measured by an active straight leg raise. Treatment conditions were cupping therapy, sham cupping, and control. Hamstring flexibility was measured pre-treatment, immediately post-treatment, and 10 minutes post-treatment. Two investigators, both of which were certified athletic trainers, where utilized to maintain blinding throughout the study. The primary investigator, who has received training in cupping therapy, performed all treatments, and the secondary investigator collected all ROM measurements.

Participants

Using data from Lacross et al.[26] who investigated cupping therapy, an effect size of 0.49 was calculated. Using an alpha-level of 0.05 and beta-level of 0.80, the results of a power analysis indicated that 24 individuals would be sufficient to determine if differences were present. Healthy individuals ages 18-30 were recruited for this study. Inclusion criteria for the participants included being semi-active (exercising ≥2 times a week) and hamstring ROM, as measured via straight leg raise, less than 80 degrees. Exclusion criteria for participants included any injury or illness during treatment time, a hamstring ROM greater than 80 degrees, allergies to adhesives, any injury to the lower extremity in the past six months and any contraindications for cupping therapy such as:

pregnancy, cancer, bone fracture, deep vein thrombosis, sunburn, abrasion, rash, or contusion.[42] Participants read and signed an Institutional Review Board approved informed consent form prior to participation in this study. Participants took a written questionnaire to ensure that they meet the inclusion criteria for the study; questions focused on participant demographics, health history, lower extremity injuries and contraindications of cupping therapy. Any participants with contraindications to the treatments were not allowed to participate in the study. If participants began to experience a negative reaction to any of the treatments they were also disqualified from continuing. Participants completed each of the treatment conditions with at least one week between conditions.

Procedure

Each participant reported three times to the research laboratory dressed in athletic shorts that allow for access to the hamstrings. On the first of three days of data collection, participants completed the informed consent form, activity questionnaire, and performed ROM measurements to screen for inclusionary criteria. Those who qualified for the study were then randomly assigned to the first treatment, which was performed during this initial data collection.

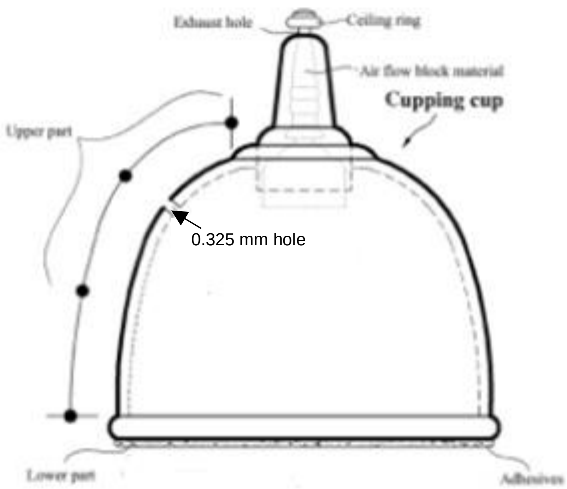
The participants were randomly assigned to either Cupping Therapy, Sham Cupping, or Control for their first condition. Randomization was achieved through a random number generator between numbers 1, 2, and 3 (1 for Cupping, 2 for Sham, and 3 for Control). In subsequent visits the treatment was randomized again, by randomly drawing the higher or lower of the two remaining conditions. The third treatment was the final remaining treatment. The treatment leg for all data collection sessions was initially selected by a random number generator of 1 or 2, 1 was for the left leg and 2 was for right. The treatment leg remained consistent throughout all three data collection sessions.

For all ROM measurements, the primary investigator covered the treatment hamstring with a stockinette to blind the second investigator who performed all ROM measurements. A rubber band was placed above the knee to keep the digital inclinometer in place, and a knee immobilizer on the measurement leg maintained knee extension. The digital inclinometer was strapped just superior to the superior pole of the patella (Figure 1). The digital inclinometer was zeroed before each straight leg raise. The intraclass correlation for the digital inclinometer is 0.84-0.95, and the accuracy of the Baseline® digital inclinometer is ±0.5 degrees.[39] The participant was secured to the treatment table using two belts, one at the anterior superior iliac spine, and the other secured the non-treatment leg at mid-thigh. A baseline hamstring ROM measure was taken on the treatment leg with the participant laying supine and performing four active straight leg raises. Participants were instructed to dorsiflex their ankle and keep their toes moving towards the ceiling to avoid any hip rotation during testing. Following the pre-treatment measurement by the secondary investigator, the primary investigator was brought into the room to administer that data collection session's randomly assigned treatment after the secondary investigator left the room.

Figure 1. Range of Motion Set-Up

After initial ROM measurement, one of three treatment interventions was performed. Cupping therapy was performed with the subject laying prone and four cups applied to the midline of the participant's posterior thigh with 0-2 centimeters between each cup. Cup size selection was determined so that the largest cups that would stay in contact with the hamstring surface before depressurization were utilized. The cup size was documented and maintained for each participant for the treatment sessions. The cups were placed beginning beneath the gluteal fold, and the final cup was placed above the medial condyle of the femur. The pressure of the cups was constant, with three full pumps from the handheld vacuum pump. The participant remained prone with the cups in place for 10 minutes. The sham cupping treatment was identical to the cupping treatment but with a different set of cups that had a 0.325 mm hole drilled into them and adhesive (Tuf-Skin®) placed along the rim to maintain skin contact during treatment (Figure 2).[43] The control condition required the participant to lay prone on the treatment table for 10 minutes, while instructed to remain still.

Figure 2. Diagram of Sham Cup[43]



Following treatment, the participant was placed supine and the primary investigator replaced the stockinette, knee immobilizer, digital inclinometer, and secured the participant for ROM measurements. The second researcher was then brought into the room to perform hamstring ROM of the treatment leg immediately post treatment. Participants remained in the ROM measurement apparatus for 10 minutes and then a third measurement was collected. Participants returned after a week between trials, at approximately the same time of day as the first trial, and with instructions to not deviate from their normal activities in between sessions for two follow-up sessions to perform the remaining conditions. The cupping sets were sterilized after each treatment application.

Statistical Analysis

The mean of the last two active straight leg raise measurements was used for statistical analysis. A 3x3x2 repeated measures ANOVA was performed to evaluate the three treatment measurements (cupping, sham, and control), the three measurements on hamstring ROM (pre, post, and 10 minutes), and sex (male, and female). The significance level was set to $P \leq 0.05$. All statistical measures were analyzed using the Statistical Package for the Social Sciences (SPSS) version 24.0 (SPSS Inc., Chicago, IL).

CHAPTER 4: RESULTS

Thirty-five individuals (female n=16, male n=19) were recruited for the study. Twenty-five (female n=10, male n=15) of those recruited met inclusion and exclusion criteria and subsequently completed the study (age: 23.52 ± 3.50 years, height: 171.89 ± 9.23 cm, mass: 72.864 ± 14.90 kg, exercise per week: 4.22 ± 0.31). Of the ten participants that did not qualify, nine were excluded due to flexibility baseline measures that did not met inclusion criteria, and one because they had already had cupping therapy performed.

Hamstring Range of Motion

Means and standard deviations of the hamstring ROM measurements for each treatment condition and at each time can be found in Table 1 and the averages can be found graphically in Figure 3. ROM, separated by male (n=15, ages: 24.33 ± 0.86, height: 177.45 ± 1.49, weight: 78.33 ± 2.71, exercise times per week: 3.93 ± 1.12) and female (n=10, ages: 22.3 ± 1.12, height: 163.55 ± 2.15, weight: 64.66 ± 5.44, exercise times per week: 4.65 ± 0.64) are reported in tables 2 and 3, respectively.

ROM was analyzed via a 3x3x2 (Condition x Time x Sex) repeated measures ANOVA, with the significance set to $p \leq 0.05$. Mauchly's Test of Sphericity was not significant for condition or time; therefore sphericity was assumed for these repeated-measures effects. Mauchly's Test of Sphericity for the interaction between time and condition was significant ($p<0.001$), resulting in a Huynh-Feldt adjustment being utilized. The interaction between Condition, Time, and Sex was not significant ($p=0.263$). The interaction effects for Condition and Sex (p=0.230), Time and Condition (p=0.443), and Time and Sex (p=0.064) were not significant. Within-subjects effects for Time (p=0.654) was not significant. There was a significant within-subjects effect for Condition (p=0.035). The effect of condition was found to be significant due to a significantly greater ROM in the cupping condition compared to control (p=0.004). Post-hoc paired-tests identified that the cupping condition had significantly greater ROM than the control condition at pre-treatment (p=0.032), post-treatment (p=0.017), and 10-minute post (p=0.006) time points. There was no significant difference between sham cupping and control (p=0.787). There was a non-significant main effect for Sex (p=0.309), indicating that male and female ROM measurements were similar.

Table 1. Participant Range of Motion (Mean ± standard deviation)

	Pre (°)	Post (°)	10 Minute (°)
Cupping	69.38±11.36	70.88±12.64	70.40±12.62
Sham	67.08±13.95	66.51±14.68	67.05±15.52
Control	66.83±10.63	67.57±12.67	66.47±13.21

Figure 3. Average Range of Motion of Treatment Conditions

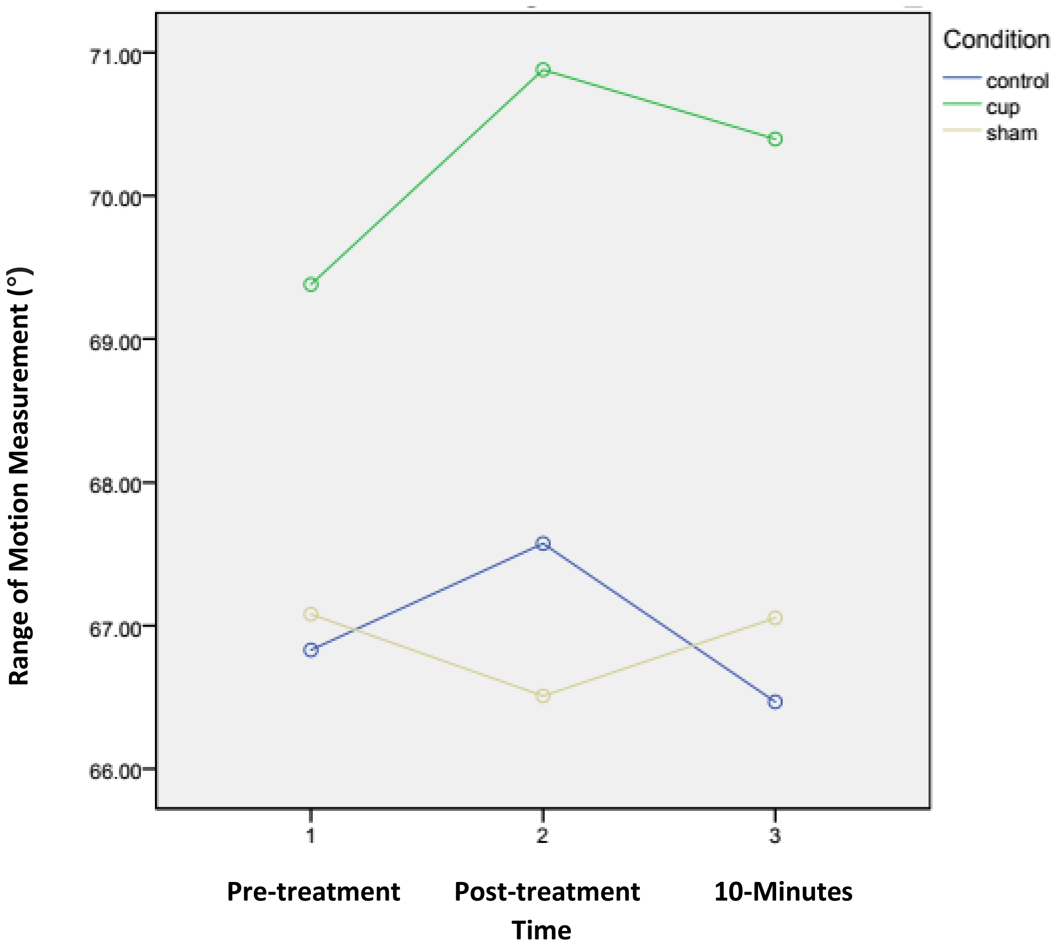


Table 2. Male Participant Range of Motion Averages (Mean ± standard deviation)

	Pre (°)	Post (°)	10 Minute (°)
Cupping	68.93±2.87	68.45±2.94	67.64±2.99
Sham	64.29±3.84	64.50±3.77	62.67±4.18
Control	66.40±2.89	66.25±3.38	64.87±3.57

Table 3. Female Participant Range of Motion Averages (Mean ± standard deviation)

	Pre (°)	Post (°)	10 Minute (°)
Cupping	70.06±3.87	74.52±4.48	74.52±4.29
Sham	71.26±3.76	69.52±4.76	73.62±3.95
Control	67.47±3.24	69.55±3.92	68.87±3.95

CHAPTER 5: DISCUSSION

The results of this study indicated that a single use of cupping therapy does not increase hamstring flexibility when compared to a sham cupping treatment or control in healthy participants. There was a statistically significant difference in ROM for the cupping condition and the control condition when measurements were combined without regard to time, but post-hoc analysis indicated that this difference was due to differences between groups and not a product of the treatment. There was no statistically significant difference when comparing the treatment conditions and time, conditions and sex, time and sex, or conditions, time, and sex. This study was unique due to the use of a validated sham condition in comparison to cupping therapy and double-blinded randomized control trial research design. Previous research on cupping therapy as an orthopedic treatment has not utilized a blinded study design.[17, 26] One goal of the current study was to explore the possibility of a placebo effect. Our hypothesizes were that cupping therapy would result in a significant increase in flexibility, which would be greater than any flexibility increases seen in the sham and control conditions immediately post and 10 minutes post treatment. In disagreement with our hypotheses, there was no significant difference in cupping therapy compared to the sham cupping or control conditions.

Although the current study did not find an increase in flexibility following cupping therapy, previous research has indicated a treatment effect. Current orthopedic studies on cupping therapy have used injured populations and found significant increases to flexibility after application.[17, 26] Markowski et al.[17] applied a single bout of static cupping therapy on the low back and found an increase in hamstring and lumbar flexibility in participants with chronic low back pain. Lacross et al.[26] applied to injured hamstrings a single bout of instrument-assisted soft tissue mobilization followed by cupping with stretching, which resulted in an increase in hamstring flexibility in athletes that had hamstring injuries. Based upon the lack of flexibility gains seen in the current study compared to the positive response to cupping therapy in the previous literature, it could be speculated that cupping therapy is an effective means to increase flexibility for patients that have an injury but not in healthy individuals with flexibility deficiencies.

Other methodological differences existed between the current study and previous orthopedic research that reported positive cupping outcomes.[17, 26] Previous orthopedic studies did not have a placebo intervention condition and control condition that only performed measurements to compare with cupping therapy.[17, 26] The methodological choices of Lacross et al.[26] made for a difficult evaluation as to which aspect myofascial treatment caused the significant increase of flexibility. This challenge stems from participants having received both instrument-assisted mobilization and stretching with the cupping application prior to post-treatment measurements.[26] Additionally, previous studies utilized a passive straight leg raise whereas the current study utilized an active straight leg raise.[17, 26] Using a passive straight leg raise provides a ROM measurement, but may not demonstrate functional ROM. Furthermore, neither utilized a blinding process which makes passive straight leg raise measurements more susceptible to an investigator's bias due to the investigator's involvement in moving the participant. We chose the active straight leg measurement to observe functional flexibility increases and allowed for any placebo effect to occur without investigator bias. The current study found using double blinding with control and sham conditions that cupping therapy did not increase ROM when using active straight leg raise. Further studies are needed to explore the use of cupping therapy that incorporates sham and control conditions, particularly in an injured population, to provide concrete evidence of the effects of cupping therapy.

There are a multitude of physiological changes that are speculated to occur with cupping therapy that influence tissue change. The orthopedic effects of an application of cupping therapy could include: an increase in blood circulation,[16] alleviate pain,[17, 18] reduce swelling,[18] regulate body temperature,[16] increase skin temperature,[19] decrease blood pressure,[19] irritate the immune system causing local inflammation,[20] and improve neurophysiological performance,[21] Furthermore, cupping has been theorized to loosen connective tissue, which could result in increased flexibility.[22] Although the current study did not directly measure these possible physiological effects, it can be hypothesized that any physiologic changes due to cupping were not enough to increase flexibility. The absent flexibility increase from the physiological responses could be due to all the participants being healthy individuals with deficient flexibility, but without injury.

An increase in blood flow and tissue temperature has been proposed to increase flexibility following other tissue mobilization techniques.[36, 37] Due to the limited research assessing orthopedic cupping therapy, previous studies using other techniques could be used to develop theoretical frameworks on the effects of cupping therapy. Multiple studies have found that other soft tissue mobilization techniques, such as instrument assisted and self-myofascial release, cause increased flexibility.[26, 36-38] Graston Technique® was found to cause a significant flexibility after an acute treatment and after a 4 week intervention study.[36, 37] Lacross et al.[26] found that a self-myofascial release treatment of less than 3-minutes after 10-minutes of moist heat pack application caused a significant increase in hamstring flexibility. Kipnis et al.[38] found a significant increase in hamstring flexibility after having healthy participants walk on a treadmill for 5 minutes. Due to the concise treatments with positive results, instrument-assisted soft tissue mobilization and self-myofascial release have been more efficient techniques than cupping therapy according to current literature.[17, 26, 36-38] Cupping therapy with stretching may prove to produce similar results in a comparable timeframe.

The current study had limitations, primarily attributed to the sham cupping set, which was comparable to a set validated by Lee et al.[43] Some participants noted the sham treatment's decreased pressure. Participants observed the change of pressure especially if they had previously had the cupping therapy treatment. The goal of the sham treatment was to have the participant feel the suction at the beginning and to gradually loss pressure so that it was not recognized. A second limitation regarding the sham cupping treatment was that the size of the cups had to be limited for both the sham cupping treatment and cupping treatment so that the cups were small enough to maintain full contact with the participant without suction. Limiting the size of the cups in the cupping therapy condition limited the amount of pressure that the cups exert on the fascia, a proposed mechanism for treatment effect. However, keeping the cup sizes constant was important to maintaining the legitimacy of the sham treatment.

An additional limitation was participants possibly changing their normal routines causing later pre-treatment ROM measurements higher than our inclusion criteria. In the present study eight participants reported on their second or third sessions with higher pre-treatment ROM measurements than was accepted with our inclusion criteria.

Of these eight participants, two received cupping during their first visit, one received the sham, and five were in the control treatment. It is unknown if any participants parted from their normal routine during the study that could have increased their flexibility.

Further research studies on the physiological effects of cupping therapy could include comparing cupping therapy with other methods to increase blood flow to an area including: an active warm-up, moist heat pack, warm whirlpool, therapeutic ultrasound, and soft tissue mobilization techniques. Another avenue of further research that could be investigated is cupping therapy with the patient moving the body part with application, or with the clinician moving a cup.

In conclusion the current study found the use of static cupping therapy did not increase flexibility in healthy individuals that had deficient hamstring flexibility. The current study found that there was no placebo effect with a sham cupping therapy. Although static cupping therapy did not result in an increase in flexibility, there is a need for further studies to explore cupping therapy with motion to explore if cupping therapy can create a positive result in additive effect with stretching.

APPENDIX A: HEALTH HISTORY QUESTIONNAIRE

Activity Questionnaire

Participant ID: ______________________________ Date: _________

How often do you exercise in an average week? ______________

What activities do you participate in the most?

____

____

____

Have you had a lower body injury in the past 6 months? _______

If yes, what was your injury? __________________________

Do you believe that you may be pregnant? _______________

Have you ever had cupping therapy? ___________

If yes, why? ____

Do you have any skin damage to your hamstring? (i.e. rash, sunburn, bruise, or scabbing). ____________________

What made you want to participate in this study?

____

____

APPENDIX B: DATA COLLECTION SHEETS

****FOR PRIMARY INVESTIGATOR USE ONLY****

Participant ID ____________________

Gender___________ Age _____________

Height (cm) __________________ Mass (kg) _________________

Completed Activity Questionnaire ☐ Informed Consent ☐

Leg__________

Visit One

Date: ___________ Time:__________

Condition: ___________________

Cup sizes used: _______________

Distance between cups: ________

Visit Two

Date: ___________ Time:__________

Condition: ___________________

Cup sizes used: _______________

Distance between cups: ________

Visit Three

Date: ___________ Time:__________

Condition: ___________________

Cup sizes used: _______________

Distance between cups: ________

Subject ID ____________________

Age _____________ Height (cm) __________________ Mass (kg) _________________

Completed Activity Questionnaire ☐ Informed Consent ☐

<u>Visit One</u>

Date: ______________ Time:__________

		Baseline Pre Test					Post treatment					10 minutes post			
	M1	M2	M3	M4	Avg	M1	M2	M3	M4	Avg	M1	M2	M3	M4	Avg
ASLR															

<u>Visit Two</u>

Date: ______________ Time:__________

		Baseline Pre Test					Post treatment					10 minutes post			
	M1	M2	M3	M4	Avg	M1	M2	M3	M4	Avg	M1	M2	M3	M4	Avg
ASLR															

<u>Visit Three</u>

Date: ______________ Time:__________

		Baseline Pre Test					Post treatment					10 minutes post			
	M1	M2	M3	M4	Avg	M1	M2	M3	M4	Avg	M1	M2	M3	M4	Avg
ASLR															

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CURRICULUM VITAE

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UNIVERSITY OF NEVADA LAS VEGAS, Las Vegas, NV
Expected Graduation May 2018
Masters of Science in Kinesiology, Athletic Training Specialization GPA: 3.73
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BETHEL UNIVERSITY, St. Paul, MN
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Clinical Experience:

Graduate Intern Athletic Trainer July 2016-Present
UNIVERSITY OF NEVADA LAS VEGAS, Las Vegas, NV
Served as primary Athletic Trainer in first year to Men and Women's Swimming and Diving, and in second year to women's soccer. Assisted coverage of Pre-season Football, Track and Field/Cross Country team and Spirit Squads. Utilized ATS for medical documentation.

Assistant Athletic Trainer August 2015-May 2016
UNIVERSITY OF MASSACHUSETTS LOWELL, Lowell, MA
Served as the primary Athletic Trainer with Women's Volleyball and Women's Lacrosse Programs. Covered recreation sport events including Men's Hockey, and Gymnastics. Utilized ATS for medical documentation.

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INDIANA STATE UNIVERSITY, Terre Haute, IN
Served as the primary Athletic Trainer with the Women's Volleyball Program. Preceptor to undergraduate athletic training students of all levels and teaching assistant for freshman prevention and care, and sophomore injury evaluation. Utilized Sportsware for medical documentation.

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