MEASURING TIBIAL ARTERY BLOOD FLOW FOLLOWING A MODERATE FIRE AND AIR VACUUM CUPPING TREATMENT

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

Cupping therapy has become a popular method of alternative medicine. However, no quantitative measures on the effects of cupping therapy on blood flow and skin temperature have been examined. The purpose of this study was to determine the effects cupping therapy on skin temperature and blood flow of the tibial artery. A pre and posttest experimental design was used. Twenty healthy males (20.70 ± 2.83 years) participated. Blood flow and skin temperatures were measured prior to and following a cupping protocol. Blood flow from fire cupping decreased an average of -3%. The skin temperatures during fire cupping increased 0.14°C ± 0.30°C. Blood flow from air vacuum cupping increased an average of 5%. The skin temperatures during air vacuum cupping did not change. The results suggest that there is insufficient evidence for the use of cupping therapy for increasing blood flow and skin temperature.

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CHAPTER I: INTRODUCTION

Tissue healing after an injury is a delicate process that is dictated by the communication of numerous types of hormones and cells.[1-4] Without these processes, remodeling of injured tissue can be disrupted and can endanger the wound healing process.[1] Consequently, following the inflammatory phase, excessive scar formation can result from incomplete wound healing.[1] Numerous therapeutic modalities such as ultrasound, diathermy, and hot packs are suggested to support wound healing.[5] An alternative treatment, cupping therapy, has yet to be supported by comprehensive research as to its efficacy in the wound healing process.

Cupping is a form of alternative medicine that dates back to the ancient Egyptians.[6] Over time, the method has been adapted to suit the uses of the practitioner. Early on, indigenous people used hollowed out horns to drain skin lesions,[7] this was followed with the use of bamboo cups by the Chinese to cleanse stagnant Qi, and in the 18th century by the Europeans to cure colds and chest infections.[6,7] The hypothesis is that cupping therapy facilitates healing by increasing blood flow and lymphatic drainage.[6] Cupping is becoming increasingly popular in clinical settings for purposes such as chronic nonspecific neck pain.[8] The most noteworthy benefits of dry cupping is that it offers both a non-invasive and non-pharmaceutical approach to treating pain. While there are many indications for cupping therapy, the biggest limitation to the expansion of the method is the lack of support in the literature. As a result, western medicine has not fully accepted cupping therapy as a medical practice.

A method that is supported by research to decrease post-surgical edema and healing time is negative pressure therapy.[9,10] Negative pressure therapy uses the concept of decreasing atmospheric pressures within subcutaneous tissues to increase interstitial fluid movement. Healing from negative pressure therapy is facilitated by increasing blood flow, angiogenesis and lymphatic fluid movement.[10,11] Though the mechanisms are largely unknown[9], it has been suggested that 125mmHg of applied vacuum achieves a maximal increase in blood flow in swine models.[11] Likewise, research suggests that when compared, there are no significant differences in either the mechanical or structural properties of swine and human skin.[12] When tested, the maximum tensile strength of swine skin has been recorded to be similar to that of human skin, and therefore is believed to be a suitable replacement for studies performed in vivo.[12]

Purpose of the Study

The purpose of this study was to determine the effects of both fire and air vacuum cupping applied at a moderate intensity on skin temperature and blood flow of the tibial artery. It is imperative to determine these effects to provide clinical evidence for the use of cupping therapy. As the practice of cupping therapy grows in western medicine, clinicians need to better understand how cupping therapy works as a treatment and the proper treatment parameters to use.

Research Questions

The primary research questions that drove this study included: Does fire cupping applied at moderate intensity increase blood flow through the tibial artery in a healthy population? Does air vacuum cupping applied at moderate intensity increase blood flow through the tibial artery in a healthy population? Comparatively, does either fire or air vacuum cupping increase blood flow through the tibial artery more than the other?

Definition of Terms

Negative Pressure Wound Therapy- A therapy that is based on the use of sub atmospheric pressures for the purpose of wound management.[10] Facilitated healing through improving rate of angiogenesis, endothelial proliferation, capillary blood flow, and decreasing interstitial edema.[10]

Cupping Therapy- A technique that uses negative pressure therapy to release rigid tissues, drains fluid and toxins, as well as brings blood flow to stagnant skin and muscles.[6]

Vasodilation- The process of a blood vessel dilating.[5]

Dynamic infrared thermography- Real time thermal imaging of the heat produced by the skin surface.[13]

Air vacuum cupping- A newer method which uses a hand pump and plastic cup to draw air into the dome once it has been placed onto the skin.[14,15]

Fire cupping- The oldest of the methods, which uses lit alcohol inside of glass, bamboo or brass cup to heat the inside of the cup. As the cup is placed on the skin, the cooling of the air inside the dome creates a vacuum towards the inside of the cup lifting the skin.[14, 15]

Importance of the Study

While increased blood flow is a reported indication of cupping therapy, there is limited evidence in the literature to support increased blood flow. To validate the use of cupping therapy for increasing blood flow, it is essential that the researchers have evidence to support local or systemic increased blood flow.

Limitations of the Study

1) The difference in leg size between subjects could affect the number of cups that can be applied on a subject. If cups are too close together, they will not properly adhere to the skin.
2) Proper location of the cups for testing. It is unknown if the ideal area for application of the cups is proximal or distal to the popliteal fossa.

3) Moderate pressure will be determined as two pumps when applied with an air vacuum cup, and immediate application from a distance of 6” with the fire cup. Unfortunately, when applying both methods, the methods are subjective and diminish the studies reproducibility between practitioners.
4) Though two different instrument types (glass cups and plastic vacuum cups) are being compared, a third instrument (silicone cups) is not being compared. Results cannot be translated to silicone cups.
5) The limited experience of the individual performing diagnostic ultrasound to measure artery blood flow. The researcher has had minimal training and experience, reliability of measurements between patients might vary more than an experienced practitioner.

Delimitations of the Study

1) Only subjects who reported being healthy and having no contraindications to the study were used as test subjects.
2) The age range of the subjects were limited to 18 to 30 years old.
3) The cups were 2” in mouth diameter for both fire and air vacuum cups. Both types of cupping were applied at a moderate suction for 15 minutes.

CHAPTER II: LITERATURE REVIEW

The purpose of this study was to determine the effects of both fire and air vacuum cupping applied at a moderate intensity on skin temperature and blood flow of the tibial artery. The research questions that guided this study included: 1) Does fire cupping applied at moderate intensity increase blood flow through the tibial artery in a healthy population? 2) Does air vacuum cupping applied at moderate intensity increase blood flow through the tibial artery in a healthy population? 3) In comparison, does either fire or air vacuum cupping increase blood flow through the tibial artery more than the other? The review of the literature is organized in the following manner: Role of blood flow in the healing process, treatment types used to increase blood flow, cupping, cupping ties to other modalities, and outcomes and future research.

Role of Blood Flow in the Healing Process

Blood is described by Martini et al[16] as a fluid which has three main purposes; distribution of nutrients and hormones, excretion of cellular waste, and mobilization of cells to protect the body from disease.[16] Some of the key components in blood are plasma and formed elements. Formed elements are predominantly categorized into platelets, leukocytes or white blood cells (WBC's), and red blood cells (RBC's).[16] Different blood elements play important roles in the healing process. These different elements and proteins perform a variety of functions ranging from hormone communication to cell growth and function.[1,2,3,4] During injury, blood flow to damaged tissue is important to initiate and maintain the healing process.

The three stages of the healing process[1] include the acute inflammatory, proliferation and maturation phases. Each of these stages overlap in a manner where the apparent end to one stage does not signal the exact beginning of another. Due to this occurrence, the healing process is a cascade of events in which the body gradually progresses and repairs itself. Initially, injury is the primary event that is needed to begin the process. Injury could be a result of breaking an arm, burning a tongue on hot food, or simply contracting a bacteria.[5] After the initial injury, the body clots the blood with platelets and vasoconstricts for the first 5-10 minutes to prevent loss of blood.[1] This marks the initiation of the inflammatory process. The inflammatory stage of healing lasts approximately 2-5 days[1] and is broken into 8 separate events.[5] Similar to the healing process as a whole, these 8 different events are interrelated and overlapping, meanwhile dependent on the previous event to stimulate the proper chemical mediators to trigger the next event to begin.

Following injury, ultra structural changes begin to occur. These changes are the result of disruption to cellular tissues causing them to die and become waste debris.[5] In orthopedic injuries, this process can occur by either primary or secondary injury. Primary injury is described as cellular death as a result of direct trauma to specific tissues.[5] Otherwise, secondary injury involves cellular death related to either metabolic or chemical processes that affect the cells in close proximity to the cells damaged by the primary injury.[5] In direct relation to ultra structural changes, chemical mediators such as histamine, bradykinin and cytokines are stimulated to moderate cellular waste removal so the repair process may begin.[5] Simultaneously, hemodynamic changes allow for the transportation of blood borne defense components to the injured and surrounding tissues.[5] The most well-known and important component triggered is leukocytes. During hemodynamic change, latent capillaries open, therefore increasing overall blood flow to the local tissue, while simultaneously slowing the blood flow rate.[5] The decrease in blood flow allows the leukocytes to then pass through the capillary wall and saturate the injured and peripheral tissues.

Consequentially, metabolic changes and secondary injury are important factors with orthopedic injuries. Secondary injury is the result of a sequence of events causing the destruction of a cell. Cells are powered by adenosine triphosphate and hypoxia forces the cells to operate by means of anaerobic glycolysis.[5] A result of anaerobic glycolysis is a decreased power output that slowly causes the cell's sodium pumps to cease function.[5] Without the ability of the cell to regulate the passive influx for sodium ions, water begins to fill the cell through osmosis, causing the cell to swell and eventually rupture.[5] Concurrently, permeability changes occur with the presence of bradykinin and histamine in the blood. With the contraction of endothelial cells, leukocytes are allowed to escape into the extracellular space along with protein rich fluids.[5] There are several consequences related to this event. With the loss of the protein rich fluids into extracellular spaces, blood viscosity increases to a point that enough cellular debris can block vessel circulation.[5] Likewise, the protein rich fluid molecules cannot be reabsorbed into the capillaries and vessels, thereby leaving large quantities of edema at the injury site.[5]

While permeability changes are occurring in the vessels, leukocyte margination involving neutrophils and macrophages is in progress. Neutrophils are small in nature and are the bodies' first line of defense against bacterial pathogens. Although effective, neutrophils are also responsible for causing secondary injury through chemical means.[5] Though many orthopedic injuries are closed and do not involve bacteria, neutrophils do serve other purposes. While concentrated in vessels, neutrophils assist in widening endothelial gaps to allow macrophages to escape vessels.[5] Furthermore, as a neutrophil dies it signals additional macrophages through chemical markers to clean up cellular debris.[5] Macrophages are larger cells that rid the body of cellular debris.[5] Eventually, phagocytosis is the final event in the inflammatory phase. Phagocytosis involves a leukocyte ingesting a piece of cellular debris or a pathogen and simultaneously uniting with a lysosome.[5] As a result, the leukocyte uses the lysosomes digestive enzymes to destroy the foreign material without damaging itself.[5]

Overall, it is important that the inflammatory stage fully progresses through all phases. Without the inflammatory stage, important chemical and growth factor signals would not be released into the blood, causing further tissue repair to be delayed or incomplete.[1] Without the cascade of events during the inflammatory phase fully residing, chronic inflammation will continue due to chemical markers activated even during mild strenuous stimuli.

Following the resolution of the inflammatory 8 phases, the proliferation phase begins. During this time, collagen and granular tissue are laid down to increase tissue strength, along with angiogenesis to resupply the injured tissue with blood.[1] These processes can take anywhere from 4-15 days to be completed.[5] Angiogenesis is the process in which the body increases capillary budding to temporarily improve nutrient and oxygen concentration to the injured tissue.[5] An increase in localized blood flow and thereby RBC concentration allows for distribution of oxygen and carbon dioxide for either cell use or excretion. Due to the body's dependency on oxygen for cellular survival, RBCs are vital to maintain and create new tissues during times of rest and injury. Furthermore, the strength and structure of soft tissues are provided with support of extra cellular matrix (ECM), granular tissue and collagen. The blood delivers proteins, neurotransmitters and other components that are crucial to form these structures.[17] By increasing the local blood supply to the damaged tissue, nutrients and chemical mediators are able to act on the healing process.

Lastly, the remodeling phase can continue from two weeks post injury up to one year.[1] During this period, the angiogenic process stops and the blood flow to the area declines.[1] Without the increased need for nutrients and chemical mediators to influence the healing process, blood flow can return to normal. Simultaneously, contraction and restructuring processes act upon scar tissue for numerous reasons. Contraction is observed when surrounding tissues compress on the scar tissue causing it to collapse and lighten due to the limited blood supply to the tissue.[5] At the same time, restructuring of tissue aids in the sunken nature of a scar by reorganizing the collagen fibers to increase its tensile strength and become more compact.[5] By increasing its own tensile strength, a scar is less likely to tear in the future and though it may not be as flexible or robust as original dermal tissue, it becomes a suitable replacement.

The healing process is a complicated and lengthy set of events used by the body to eliminate damaged cells and return tissues to pre injury function. Without the healing process, injuries would never repair and chronic pain as well as inflammation would set in. Initiation and completion of the healing process after injury or for therapeutic purpose is vital for full recovery of tissue damage.

Types of Treatments for Increasing Blood Flow

Increased blood flow to injured tissue is vital to deliver key nutrients and other healing properties to the damaged area. To aid this process, healthcare providers use a number of modalities and alternative methods. These techniques can stimulate local or systemic blood flow. Modalities that achieve this effect include therapeutic ultrasound, shortwave diathermy, various superficial heating modalities and massage.

<u>Thermal Ultrasound</u>

Both tissue temperature and blood flow are thought to be influenced by therapeutic ultrasound.[18,19] Due to the increased tissue temperature, the body's natural response is to vasodilate blood vessels. Vasodilation allows for dissipation of excessive heat from the treatment site. However, a result of the increased blood flow to the treatment site is increased nutrient concentration and metabolic waste removal.[18] On the contrary, research regarding therapeutic ultrasound and blood flow has been conflicting when performed on animal models[19] and in vivo.[20]

Baker et al[18] looked at the effects of therapeutic modalities on blood flow in vivo. To obtain the results, the authors used a Minnesota Impedance Cardiograph applied over the calf. However, the authors did not mention the depth the test measured. After the ice and heat treatments were applied, a Medcosonolator was applied for five minutes, no other parameters were reported.[18] More so, while using ultrasound as a stand-alone treatment, Baker et al[18] reported using a five minute treatment at 1.5 W/cm^2 and no further mention of treatment parameters. In summary, Baker et al[18] reported using ultrasound alone or using an ice pack before ultrasound increased blood flow compared to the control group. Additionally, the researchers reported a hot pack for 20 minutes prior to ultrasound decreased the effect of the ultrasound treatment.[18] A physiologic explanation for this might be that the participant's bodies had adapted to the temperature increase during the primary treatment and therefore was at optimal vasodilation to disperse the heat. Although the ultrasound parameters and target tissue depths were minimally reported, overall blood flow was increased as a result of the treatment.

In addition, Fabrizio et al[19] reported the most significant treatment parameters to be 1 MHz at 1.0 and 1.5 W/cm^2 that resulted in an average of 13% increase in local blood flow at 5 minutes. These numbers were compared to 3 MHz at 1.0 and 1.2 W/cm^2 which only averaged a 1.1% increase in local blood flow at 5 minutes.[19] The authors stated that a dual frequency bidirectional ultrasound Doppler placed over the popliteal artery was used to obtain the blood flow measurements. A limitation of the Fabrizio et al[19] study was the lack of description at what depth blood flow was measured with the bidirectional ultrasound Doppler. While no literature supporting the reliability and validity for the use of bidirectional Doppler ultrasound was presented, other sources have indicated significant reliability with the method.[21] Shoemaker et al.[21] examined the reproducibility of the Doppler ultrasound measuring mean blood flow on the brachial artery. In result, the authors[21] stated that mean blood flow variability could be reduced from ~17% to 12% when their first trial was removed from their analysis. It was determined that certain requirements were paramount to attaining reliable and reproducible data. These conditions include well-rested participants, an experienced Doppler sonographer and ambient room temperature.[21]

While Fabrizio et al[19] reported 1 MHz ultrasound was more effective at increasing blood flow, Strand et al[22] reported 3 MH increased blood flow. Strand et al examined the effectiveness of a 3 MHz treatment at 1.0 W/cm^2 with 100% duty cycle for 5 minutes and the effect on blood flow at a tissue depth of 1.0 cm. Tissue temperatures were indicated to have risen 3.77° C[22] based on previous research. More importantly, local blood flow increased from 11.186 cm/sec ±11.555 to 16.484 cm/sec±9.410, which was a 47% increase. Blood flow rate was determined through the use of diagnostic ultrasound and a measurement of time-averaged mean velocity.[22] While comparing Fabrizio et al[19] and Strand et al[22], it is apparent that further research needs to be performed on ultrasound depth of penetration.

Results supporting an increase of blood flow by use of therapeutic ultrasound were also found in the upper trapezius muscle. Morishita et al[20] used near-infrared thermography to detect changes in hemoglobin and deoxygenated hemoglobin in the superficial muscle tissue. The authors reported an increase in hemoglobin levels up to 20 minutes post treatment[20], though the researchers also reported no change in deoxygenated hemoglobin levels during the treatments. These results are intriguing because they suggest that as arterioles vasodilate, oxygen rich blood flow is increased to the local tissue.[20] A limitation to this study was the lack of description regarding the depth of penetration of the near-infrared thermography unit. The unit was described as penetrating superficial tissue; however, there were no numerical descriptions as to the exact depth. The authors did report using an EU-940 ultrasound unit set to superficial heating parameters during the ultrasound treatments. During the study, 3 MHz, 1.0 W/cm^2, 100% duty cycle for 10 minutes was applied as the treatment. If the depth of penetration for a near-infrared thermography unit was described, reliability for this study might be able to be determined. While some studies support the use of therapeutic ultrasound for soft tissue healing and increased blood flow[18,19], others refute it.[20] Overall, the quality and methodology of studies need to be improved to make more sound conclusions on the efficacy of therapeutic ultrasound.

Shortwave Diathermy

An alternative to ultrasound for achieving deep heating is shortwave diathermy (SWD).[23,24,25] Deep heating modalities are described to have therapeutic effects at 2-5cm below the dermal surface.[25] Shortwave diathermy is radio frequency waves that induce rapid movements of ions in the target tissue to increase heat.[24] Numerous authors report the use of SWD has been substantiated by clinical results to increase tissue temperature, collagen synthesis and connective tissue healing.[23,26] However, other authors report either mixed results or flawed studies.[24,27] Most importantly, research supports that SWD increases tissue temperature and thereby blood flow and vasodilation.[23,25,26,28]

Unfortunately, there is conflicting evidence that pulsed short wave diathermy (PSWD) increases blood flow and accelerates healing.[28,29] A component of PSWD that remains unanswered is whether or not therapeutic doses are thermal or non-thermal in nature. Draper et al[28] examined the thermal effects of the Megapulse II PSWD and ReBound diathermy units. The

ReBound diathermy utilizes a sleeve with conduction coils to surround the treatment area with continuous energy during the 30 minute treatment.[30] In comparison, the Megapulse II PSWD uses a drum placed above the target tissue at 800 pulses per second with a pulse width of 400 microseconds.[28] Furthermore, the ReBound diathermy unit operates with a peak wattage of 35 W while the Megapulse II can produce up to 48 W.[28,30] At the conclusion of the study, the authors reported that both units were effective at heating muscle tissue to therapeutic levels.[28] The Megapulse II PSWD unit heated tissues at a depth of 3cm to 4.32±1.79°C, while the ReBound unit achieved a 2.31±0.87°C increase.[28] When compared to literature recommendations for achieving therapeutic temperatures, as little as a 1°C increase in temperature is associated with increased cellular metabolism.[5] Additionally, a 2-3°C change increases local blood flow to tissues.[5] In conclusion, this means that both diathermy units tested properly increased tissue temperatures enough to facilitate healing through increased cellular metabolism and concentration of key nutrients transported by the increased local blood flow.

In addition, Garrett el al[25] compared the heating abilities between a 1.0 MHz ultrasound treatment with an Omnisound 3000C ultrasound and the Megapulse diathermy unit. The results support the results presented by Draper et al.[28] The authors used three thermistors placed at a depth of 3cm and spread 5cm apart in a linear fashion along the medial triceps surae. When the ultrasound intervention was being performed, a 20 minute treatment at 100%, 1 MHz with an intensity of 1.5 W/cm^2 were selected as the parameters.[25] Likewise for the diathermy treatment, 800 bursts per second at 400 microsecond burst duration, with an average of 48 W per burst for a 20 minute treatment were the selected parameters.[25] The Megapulse diathermy unit averaged temperature increases of 3.02±1.02°C at site one, 4.58±0.87°C at site two, and 3.28±1.63°C at site three.[25] Though numbered, the sites were not specified in their orientation on the medial triceps surae. On the other hand, the Omnisound 3000C recorded tissue temperature changes of 0.17±0.40°C, 0.09±0.55°, and -0.43±0.41°C.[25] Clearly, at a depth of 3cm, the Megapulse diathermy unit was more effective at treating deep tissues to a therapeutic level therefore increasing cellular metabolism and blood flow. A significant limitation to the study however was that the treatment area of the ultrasound was determined by tracing the diathermy drum resulting of a 40 ERA treatment area (equivalent to a 200Cm^2 area).[25] The recommended ERA for ultrasound is approximately 2-3 times the sound head.[5] As a result, the ultrasound was applied to an area larger than the recommended treatment area to obtain proper therapeutic effects. To properly utilize a sufficient level of intensity for treatment, additional studies are necessary to explore the effects of varying intensities of SWD on healing.[23,29]

Comparatively, Brown et al[26] examined the effect of SWD on injured rabbits' gastrocnemius muscles. After administering the treatment, the rabbits were anesthetized and the gastrocnemius muscle was bisected. Furthermore, half of the gastrocnemius muscle was frozen while the other half was prepared to be viewed by a microscope. They concluded that administering SWD for eight consecutive days had no impact on the healing of muscle tissue, but a healing trend began to occur after 16 days.[26] Despite the results, there were a few limitations to these observations. Primarily, there was no description to what was considered a healing trend and how that was measured. Yet, Brown et al[26] noted that the short wave diathermy intensity levels administered were very low levels. Using a rectangular (18x33 cm) induction drum, the rabbits' gastrocnemius was placed in the center of the magnetic field. The Magnatherm SWD machine has a maximal strength of 250 watts, and can be set to power settings between 1 and 12.[26] At a power setting of one, it was reported that only 15% of the total maximal power output was being used by the Magnatherm.[26] Likewise, at a power setting of eight, only 57% of the total maximal power output was being used by the Maganatherm.[26] Upon review of their methods, less than 57% of the maximum energy output was applied to the injured tissue until day 10 of the healing process. This could be an important factor in their results regarding the length of time tissues began to show increased healing.

While some studies showed therapeutic effects of short wave diathermy,[25,28]some did not.[26] A few factors that could be limiting results were varying treatment parameters, animal vs. human trials, and the injury status of test participants. Without continuity between studies it is difficult to conclude the reliability of results. Future studies need to standardize patient population, injury status during testing and treatment parameters to increase the validity and reliability of studies produced.

Hot Pack

Current research suggests that moist hot packs can be used for numerous benefits. These benefits range from increased tissue temperature and increased blood flow to increased cellular metabolism.[18, 31, 30,32] Moist hot packs are considered a superficial heating modality with a capability of increasing tissue temperature by 2.2-3.8° C at a depth of 1cm.[30] While most research supports the effects of moist hot packs, the length of treatment time is the most disagreed upon treatment parameter. Both Baker et al[18] and Petrofsky et al[31] stated the standard 15 minute treatment time might not be the proper length of time to achieve maximum effects.

Petrofsky et al[31] examined the effects of a standard Chattanooga hot pack with dimensions of 25cm by 30cm applied with varying towel thicknesses between 2mm and 10mm. To record temperatures, Petrofsky et al[31] used surface and intramuscular thermistors placed 2.5cm below the skin. Temperatures in both the quadriceps and the gastrocnemius muscles were measured. The hot packs were maintained at 75°C. The first group was labeled as thin, and were categorized as individuals between 8 and 24% body fat.[31] The second group was labeled overweight and had between 25 and 60% body fat with an average of 35%.[31] Hot packs were applied for a total of 20 minutes. In result, the authors[31] found that the thin group's tissue temperature increased from between 4°C with 10mm of toweling and 8°C with 2mm of toweling. On the other hand, the overweight group increased from 1°C with 10mm of toweling to 5°C with 2mm.[31] This is due to a number of factors. The thickness of towel wraps is a common drawback of moist hot packs. Towel thickness as little as 1mm can inhibit the transfer of heat through conduction from a hot pack to the dermis and underlying tissues.[31] Another limitation to heat transfer between the modality and tissues is body fat.[31] Though unalterable, body fat decreases the effect of heat transfer because of its insulating effect.[31]

While the temperatures reported were all clinically significant, there are a few flaws to this study. Foremost, the thermistor was placed 2.5cm below the skin surface, not below the adipose layer. This means that for both the thin and overweight subject groups, each individual had the thermistor placed in a different layer of tissue. This creates inconsistency with the reporting of tissue temperatures. Lastly, the authors[31] noted that temperatures still had not stabilized by the end of the testing. Therefore, they were drawn to the conclusion that a 20 minute hot pack treatment was not adequate for tissue heating.

In contradiction to both Baker[18] and Petrofsky et al,[31] Hawkes et al[30] compared PSWD and moist hot packs at superficial depths[30] and examined the effectiveness of a 30 minute treatment and 20 minutes of decay post treatment with both modalities. The authors[30] inserted a thermocouple 1cm into the triceps surae. The mean triceps surae skinfold for Hawkes et al[30] was 7.2mm. For hot packs, tissue temperatures peaked at 20 minutes and overall rose by 2.82°C± .90°C [30] On the other hand, tissue temperatures for the PSWD surpassed those of the hot packs after 20 minutes and had an overall increase of 3.69°C± 1.50°C.[30] Each subject underwent testing for both the SWD and hot pack interventions. Testing for each intervention was completed on separate days, however the exact time between measurements was not discussed. Furthermore, Hawkes et al noted that 20 minutes after both treatments were ceased, the moist hot packs tissue temperature remained higher than that of the SWD.[30] It is possible that because of the overall temperature of the SWD treatments, the body's natural reflex of vasodilation effectively dispersed the heat from the treatment site. The effects of vasodilation are important because not only does vasodilation disperse heat, it allows for increased blood flow to local tissues resulting in increased nutrient density to the local tissues. During the healing process, it is essential to provide necessary nutrients, as healing stages are highly sensitive to the interaction between cells, proteins and bioactive molecules.[2,2] Without the proper molecular interaction generating tissues, excessive scarring and chronic wound formation can occur.[2]

A less studied element of blood flow is molecular distribution. Okada et al[32] examined oxygen saturation, oxygenated and deoxygenated hemoglobin, as well as total hemoglobin in the masseter muscle before and after treatment. A three wavelength near-infrared spectroscope set at the wavelengths of 700, 750 and 830nm was used to measure the treatment outcomes. The depth of penetration was between 10 and 25mm below the skin surface. A Nexcare ColdHot Pack was heated to 55°C and applied to the masseter muscle via a belt case for 20 minutes. This treatment group was compared to a control group of a 37°C hot pack applied using the same methods. Ten to fifteen minutes post hot pack removal, the total hemoglobin was significantly increased over the basal rates.[32] Furthermore, oxygen saturation and oxygenated hemoglobin was increased from the time of hot pack removal up to 20 minutes afterward.[32] These results suggested that the muscle and tissues were using the available cell components. Overall, the study exhibited that blood flow was influenced by the hot pack as a result of the increased oxygen consumption.[32] When evaluating moist hot packs applied at superficial depths, results from studies suggest that tissue temperatures are therapeutic in nature.[33] More importantly, these therapeutic temperatures allowed for increased blood flow bringing necessary nutrients to promote tissue healing.

Massage

Massage therapy is a commonly used practice to aid muscle recovery after competition. Treatment types include effleurage (unidirectional strokes used to relax patients), petrissage (kneading of muscle tissue), tapotement (hacking) and vibration, among others.[5] An important goal of massage therapy is to increase tissue temperature and blood flow, as well as decrease resting muscle tension.[34, 35,36] Increasing local blood flow to muscles is essential for the patient to allow the body to excrete unnecessary metabolic wastes that result from exercise.[34] Unlike other methods of increasing blood flow, research regarding massage therapy has been highly inconclusive and contradictory.[34,35] Reasons for the inconclusiveness of evidence for massage therapy are primarily based upon the methods of data collection and interpretation. A common remark by numerous authors regarding their own conclusions or that of others is blood flow has a tendency to be measured indirectly via skin temperature.[13,34,35] A number of concerns exist that are associated with this method. A few studies have measured blood flow indirectly though skin temperature.[13,35] Without numerical data to support the claim of increased blood flow, it is hard to reasonably conclude the relationship between skin temperature and blood flow. Similarly, it is unclear what role skin temperature plays on blood flow, which makes more direct measures of measuring blood flow necessary for further studies.[35]It is problematic when attempting to create treatment parameters if clinicians are unable to recognize the limitations of the therapy.

Despite the limitations to a number of studies, others have established support for the use of massage therapy. Portillo-Soto et al[35] concluded massage therapy was effective at increasing skin temperature and blood flow. Participants received a 10-minute treatment of either massage or Graston. Afterwards, a wireless VitalSense dermal temperature patch was applied to the skin over the gastrocnemius. The authors indicated that up to 25 minutes post treatment, skin temperatures continued to remain elevated for both treatments.[35] The massage treatment leg was elevated by 1.77°C greater than the control leg and the Graston treatment leg remained elevated by 0.84°C greater than the control. These results support the clinical use of massage for therapeutic effects.

Regardless of the findings, a few limitations to the methodology and results were evident. Unfortunately, the study does not describe the exact massage technique used nor does it describe the tools or techniques used for the Graston treatment. Without this information, it is difficult to know whether or not the interventions were applied correctly. In terms of results, the authors reported the increased skin temperature was not to a therapeutic level of at least 1°C increase.[5] Also, it cannot be inferred that the heating of skin temperature will affect deeper soft tissue the same as superficial. The results suggest massage can be mildly therapeutic on superficial tissue; however, it does not support the use of Graston for increasing skin tissue temperature. More so, the most significant limitation to this study is the lack of evidence for increased blood flow. While the authors did mention that skin tissue temperature increased, they did not directly measure blood flow. As a result, the absence of measured blood flow creates a significant limitation to the studies claims.

Likewise, Sefton et al[13] used Dynamic Infrared Thermography to measure skin temperature change after a 20 minute massage protocol. The protocol was performed on 13 defined massage zones. These massage zones were listed as cervical/upper chest, anterior and posterior right and left arm, anterior and posterior right and left hand, pectoral/upper abdominal, upper back, and posterior thoracic. Five of the thirteen massage zones significantly increased skin temperature after massage therapy more than the control group. The zones listed as increasing skin temperature were anterior upper chest (0.4°C), posterior neck (0.8°C), upper back (0.6°C), posterior right arm (0.6°C) and middle back (0.6°C). Notably, the posterior right arm and middle back zones were not directly treated by the protocol; however, they showed an increase in skin temperature post-massage.[13] This is a significant result because it implies that massage can influence tissue outside of the treatment area. However, a limitation of this study is the lack of overall rise in tissue temperature. While the results were considered statistically significant, they are not considered clinically significant. According to Knight & Draper[5], thermal modalities must reach a minimum temperature of 1°C above baseline to be considered therapeutic and clinically significant. It is possible, however, that the massage could provide other therapeutic effects such as relaxation, decreased muscle tension and spasm.[5] Though there were temperature increases in the different massage zones that were considered statistically significant, they were not clinically significant.

Adversely, others have determined that a reduction in blood flow[36] or no effect on blood flow[37] occurred during massage therapy. Wiltshire et al[36] examined the relationship between the use of massage, active recovery and passive recovery on lactic acid removal post exercise. Passive recovery involved resting after isometric handgrip exercises for 10.5 minutes. Active recovery required the subject to rest for 30 seconds followed by rhythmic contractions for 10 minutes at 10% of their maximal volumetric contraction. Visual feedback was provided through a monitor to help prevent excessive effort during the recovery period. Lastly, the massage group was instructed to relax for 30 seconds and then received a 2.5 minute effleurage treatment followed by 5 minutes of petrissage and another 2.5 minute effleurage to finish. Eleven of the twelve subjects completed each of the test conditions the same day. It was required that the subjects lay supine for a minimum of 10 minutes between each condition to allow their baseline values to return to normal.

Through the use of a Doppler ultrasound probe placed over the antecubital fossa during recovery, the results indicated massage reduced blood flow for up to 3.5 minutes post exercise and active recovery by 1.5 minutes.[36] It was theorized that compression of the muscular tissue surrounding the artery hindered blood flow. Reduction in blood flow was determined by measuring impedance in the brachial artery through use of the Doppler ultrasound probe. Notably, the analysis reported that after 4.5 minutes post exercise[36], there was no statistical difference between the rest, massage or active recovery groups. There was no discussion of the clinical significance. Furthermore, this suggests that over a short period of time, massage would neither be helpful nor harmful to recovery. Lastly, the authors did conclude that compression of tissues during active recovery caused by muscular contractions and massage therapy impaired blood flow and therefore removal of metabolic wastes. It is important to note that during the exercises, forearm blood flow increased from a baseline of 100ml/min to 550-800ml/min (Figure 6A). This is significant because even though the massage recovery group didn't increase blood flow post exercise, the same results may not be found in subjects at rest.

Massage therapy is another technique that is debated within the literature regarding its efficacy for increasing skin temperature and blood flow. While some results suggest increased skin temperatures[35,13], others refute the effect increased blood flow.[36,37] A methodological mistake seen in massage therapy studies is claiming increased blood flow as implied by increased skin temperature rather than a direct measurement. Overall, more quality studies regarding massage therapy and its effects are needed to support or refute claims.

Cupping

History

Cupping is one of the most practiced therapeutic treatments in the history of the world. It originates back as far as 3,500 years ago when it was utilized by the Egyptians to cure anything from the common cold to gynecological disorders.[6,7] Over time, cupping began taking root in countries such as Asia, Africa, Europe, the Americas and even Australia.[38] As cupping evolved over time, so did the use of various types of instruments. Anywhere from animal horns to bamboo cups, glass, plastic and metals have been all used at one point to cure the ailments of patients.[38] In Europe, it was thought that wet cupping, scarring the skin with a blade to produce bleeding, would help cure colds, infections and many other ailments.[6] Similarly, there are many other western theories for the use of cupping. Some of these theories include the use of cupping as counter irritation to trigger points, increased blood flow, decreased neural sensitivity, and mobilization of lymphatic fluids.[6,38]

Currently, no certification is required by the FDA or any other organization to be able to purchase supplies or apply cupping techniques. However, both the International Cupping Therapy Association (ICTA)[39] and ACE Massage and Medicupping[40] offer workshops worldwide to learn and expand skills for cupping. Over 10 domestic and international continuing education regulatory boards formally recognize the ICTA.[39] Training varies depending on the level of class attended but classes can range from a single eight hour day to a three day course that includes 24 hours of instruction.[39] Each class is provided with hands on instruction and practice, though online and CD courses are available.

Cupping Methods and Instruments

Over time, clinicians have developed different types of cupping instruments with their own uses. The oldest method of cupping is fire cupping.[6,14] This involves using a bamboo or glass cup along with a cotton ball saturated with rubbing alcohol to generate heat. Once the cotton ball is saturated with rubbing alcohol, it is lit on fire and placed into the dome of the cup. Then, the flame is removed from the cup and the cup is applied to the skin. The cooling of the air inside the cup then creates a vacuum which draws the skin up into the cup.[14,41] The other method of cupping involves an air vacuum. Two different instruments used for the air vacuum method involve either hard plastic cups with a hand pump or soft silicone cups which have a dome that when deflated and placed over the skin will create a negative pressure vacuum.[15] Flexible silicone cups are used to comfortably glide over muscle tissue and bony prominences.[6] Depending on the clinicians intended effects; various types of cups are available to fit a multitude of purposes.

Along with the different instruments, the methods that are used each have a purpose. Principally, there are two main types of cupping, wet or dry. Wet cupping involves placing a stationary cup on the patient for a period of time, scarring the skin and re-applying the cup to remove subcutaneous blood.[14] This type is still quite popular in Middle Eastern and Eastern medicine. However, this type is much less popular in western philosophy. On the other hand, dry cupping uses the same methods of application for the cup (fire or air vacuum), however, the skin is left intact throughout the treatment therefore maintaining the skin barrier and not creating a risk for infection.[14,42]

Under the category of dry cupping, a variety of techniques such as stationary, gliding and flash cupping can be applied and manipulated for different effects. Stationary cupping is the most basic of cupping techniques. This technique refers to using any variety of cup to create a negative pressure vacuum in a single location for therapeutic effects.[7] For more of a systemic approach, a clinician can employ the gliding technique. This technique requires the use of lubricants such as massage oil or lotions to allow the cup to be moved and smoothly glide across the skin during treatment.[14] There are a few advantages to this technique. Primarily, this technique allows the clinician to have a broader treatment area. Likewise, the motions of this technique resemble a deep tissue massage. Effects of this technique are predominantly aimed at loosening systemic facial and muscle restrictions along with increasing blood flow, thereby increasing nutrient density and excretion of metabolic wastes.[6] As a part of the technique, it was taught by the ICTA that when moving a cup during gliding, lifting the cup, not pressing on it, would provide the best separation of tissues.[43] Lastly, flash cupping is another technique than can be used. This technique is used by creating a negative pressure seal on the patient's skin and quickly breaking that seal by pulling the cup straight off the skin creating an audible "pop". This method resembles tapotement or vibration massages and is commonly used for relaxation and to aid plural congestion by loosening mucosal flem and increase expectoration.[21,43]

Along with different techniques, parameters such as number of cups used, amount of time applied to the skin and frequency of cupping are all important factors to a patient's recovery. Generally, anywhere from four to ten or more cups may be used per session by a clinician to treat the injury depending on the size of the treatment area.[7,38] The total time for cupping, however, is a disputed treatment parameter. Some sources claim cups are typically left on anywhere from 5-15 minutes.[7,14,38] Others, such as the ICTA Handbook,[6] recommend anywhere from 5-30 minutes based upon numerous factors. These considerations include age of the patient, depth of treatment, and current patient response to the treatment. For the ages of seven and under, the ICTA[6] recommends weak to medium suction with a maximum of 5 minutes of treatment time. For 7-14 year olds, a weak to medium suction is recommended and 10 minutes maximum treatment time. For individuals 15 years old and up, a weak to strong suction is recommended and 15-30 minutes of treatment time, depending on the response to the treatment. Unfortunately, the biggest problem with the ICTA's recommendations[6] is that they are all subjective and not numerical or measureable. Lastly, after every cupping session, lymphatic drainage should be performed over the treatment area.[6] The draining technique should always be directed towards the nearest cluster lymph nodes (i.e. inguinal lymph nodes for lower extremity treatments or axillary nodes for the upper extremity).[43] Lymphatic draining should always be performed with light suction and using the gliding technique.[43]

It is recommended by the ICTA[43] that when cupping someone for the first time, light to moderate pressure should be applied to allow the patient to become accustomed to the treatment. The longer the cup is applied to the skin, the more severe the effects will be. Tissue effects are typically observed by localized and circular ecchymosis, edema and erythema.[38,14,41,15] These bruises can take anywhere from a few days to a few weeks to heal and disappear. Though considerations and treatment parameters are provided, no recommendations are offered regarding the length of treatments to achieve particular effects such as increased blood flow, increased lymphatic flow and relaxation of muscles.

Mechanical Effects

Understanding the mechanical effects behind cupping is important to properly determine cup size and pressure to obtain the desired outcome. Typical cups range between 38mm and 50mm.[42] Unlike massage that uses compression to break tissue down, cupping uses negative pressures to create a skin uplift and separate tissues.[9] This is believed to allow for a gentler loosening of adhesions and separating of connective tissue while facilitating blood flow and mobilization of cellular waste and lymphatic fluid.[6] Within the cup, there are a few different types of pressures that are exerted. Underneath the rim of the cup are compressive forces due to the vacuum within the cup sealing it to the skin.[41] However, as discussed with negative pressure, inside the dome of the cup are tensile forces separating the epidermis, dermis and subcutaneous layers of tissue.[41]

Tham, Lee and Chu[41] suggest using the largest cup size that will fit on the targeted tissue. Though their study may be the result of only a single subject, the authors used a finite-element model to predict and calculate the forces applied to tissues during a clinical trial. For the trial, a cup with an internal diameter of 44.8mm was applied over the forearm. Two trials were then performed using a hand pump. The first trial was a single pump and the second was two pumps of the manual hand pump. The authors estimated the vacuum pressure applied with the use of Boyle's Law ($P_iV_i=P_fV_f$) and determined the internal volume of the cup and internal pumping chamber at an efficiency of 60-65%. Boyle's law describes that as the volume of a container increases, the pressure of the gas inside proportionately decreases and vice versa. As a result, the first trial vacuum pressure was estimated to be 141mbar (one pump) and the second was 254mbar (two pumps). Approximately 300mbar was determined as a moderate vacuum pressure.[41] As determined by the finite model, soft tissue underneath the cup and just beyond the outside edges of the cup were under tension.[14] Also, the model indicated that normal stresses increase and decrease in correlation with cup size.[14] For example, a 1" diameter cup would have less stresses applied by negative air pressure than would a 2" diameter cup. Furthermore, as tissue depth increases, normal stresses are reduced across all cup sizes.[14] In summary, the authors suggested to use the largest cup that can be anatomically supported.

Furthermore, Hendriks et al[44] examined skin displacement in relation to aperture size and pressures exerted via a negative pressure system. With the use of optical coherence tomography along and 1mm, 2mm, and 6mm apertures, they were able withdraw air through the suction chamber and measure skin displacement. The authors[44] then used a finite element model software program to determine the mechanical properties of skin tissues.

A significant result of the study was the determination of an inverse relationship between aperture size and pressure necessary to cause skin uplift. The authors reported that a 6mm aperture with a suction pressure of 20kPa (equal to 200 mbar) was able to create 0.8mm of skin uplift.[44] In comparison, 1mm and 2mm apertures at a suction pressure of 35kPa (equal to 350mbar) were only able to exert 0.15 and 0.2mm's of skin uplift, respectively. This is noteworthy because the results suggest that a larger cup would require less pressure to achieve the same or more skin uplift than a smaller cup, and overall can achieve higher pressures than a small cup. These results agreed with the recommendations of Tham, Lee, Chu.[41] Clinically, this is significant because beginning a patient at lower pressures is ideal to allow them to become accustomed to the treatment. Likewise, if less pressure is needed to achieve the desired treatment parameter, the clinician has more flexibility if an increase in treatment intensity is necessary. For instance, if a one inch cup applied at moderate pressure achieves the same effects as a two inch cup at light pressure; the two inch cup has more versatility because it can still be applied at moderate and strong pressures where as the one inch cup can only be further applied at strong pressure. The main limitation of the Hendriks et al[44] study that is noteworthy is the age of the subjects. With such a wide age range of 29-47 years old, it is possible that different skin health and quality could have affected the outcome measures.

Their results indicated a correlational relationship existed between aperture size and tensile forces exerted on the target tissue. The authors noted that with the smallest aperture, only the upper layer, epidermis, was drawn into the aperture while the reticular dermis was not affected. Otherwise, when the largest aperture was applied to the skin, both the upper layer and reticular dermis were drawn into the aperture.[44]

Physiological Effects

Though the benefits of cupping have been documented for centuries, the physiological effects of cupping have been a long debated topic upon healthcare providers and clinicians through the ages. A longstanding Chinese theory for the use of cupping involves a life force known to the Chinese as Qi.[41] When this Qi becomes "blocked" within the body, it causes sickness and disease within the individual. By using cupping to allow Qi to become mobile again, a clinician can restore inner balance to the patient thereby curing the sickness.[41] In western medicine, this is an alienated theory for the use of cupping. Primarily, the lack of studies and data that have been performed using cupping therapy is scarce in the literature. In western medicine, a high premise is placed upon having quantitative data to support the use of therapies. Others simply believe in the psychosomatic theory and that cupping is simply used as a placebo effect.[38]

Regardless of beliefs and opinions, it is taught that cupping therapy has numerous effects on various areas of the body such as the skin, muscle, lymphatic system and nervous system. The ICTA[6] teaches cupping will increase blood flow, facilitate the excretion of lactic acids from muscles and desensitize hypersensitive points in the body. While these results are theoretically possible, there is an undeniable gap in supporting literature. While unsupported by the literature, increased blood flow to the skin can clinically be seen in regards to the circular marks left after treatment. These are the result of ruptured capillary vessels and toxins brought to the skin via the negative pressure.[14] Others believe that these marks are specifically not bruises but locations of stagnant Qi and built up biological waste products.[6] By improving the quality and quantity of studies regarding these possible effects, the literature could shed more light on the tangible results of cupping such as increased blood flow, decreased lactic acid concentration in muscle tissue and desensitized muscular trigger points.

Negative pressure therapy is one of the many options to treat post injury or post-surgical edema.[9] Though the exact mechanism is unknown, the purpose of negative pressure therapy is to facilitate movement of interstitial fluids to the lymphatic system.[9] In particular, Iivarinen, Korhonen and Jurvelin[9] reported that continuous suction combined with constant change in treatment position improved fluid movement and pressures. To arrive at this conclusion, the authors used both a finite element model and in vivo trials. The in vivo trials were performed on the healthy subjects' dominant forearm. Both continuous and cyclic or intermittent cupping protocols were performed using an ellipse shaped suction head measuring 28mm and 43.5mm along its short and long axis.[9] An infrared light sensor was used to measure the skin deformation. Unfortunately, the authors did not describe the exact protocols performed on the subjects. Also, the impact of a healthy vs. sick or injured individual was not discussed in terms of a fully functioning lymphatic system.

While the specific procedures were not discussed, the authors made some important suggestions based upon their findings. The authors reported that transient fluid velocities were up to 96% lower than those when the continuous cupping protocol was applied.[9]They also reported that free fluid was transported more efficiently through porous tissue by continuous cupping and movement of the cup in a single direction.[9] This finding is important because it suggests that the direction of interstitial fluid can be influenced. Furthermore, this substantiates the need to drain tissues after treatment. Lastly, when using a simulated model of 0.2mm, 1.2mm and 2.2mm of dermal compression prior to suction, 1.2mm and 2.2mm of compression lead to 20.5 and 37.4% less separation of underlying tissues.[9] These findings suggest that while performing a cupping protocol, lifting, not pressing, on the cup is optimal to achieve maximal subcutaneous tissue separation.

Possible Complications or Contraindications

Though uncommon, there are some possible complications that can arise from cupping treatments, along with a variety of contraindications. While rare and the cause unknown, blisters from cupping have occurred.[6] In one particular instance it was determined that atmospheric pressure change from flying caused an increase in vacuum pressure under the cups.[15] More likely, a complication from fire cupping that has been documented is burning of the skin during application of the cup.[15] Burning can occur a number of ways. The most common way that it can occur is the flaming cotton ball is held at the rim of the cup rather than the inner dome. During application, the patient's skin is then burned when the cup placed on the skin. Other less common ways patients have received burns are spilling jars of alcohol or excessive application of alcohol to the inside of a cup.[15] For treatments of burns, immediately remove the cup and run the burn under cold water or apply a cold pack to the area.[6]

Although complications from cupping treatments are rare, there are a number of situations where cupping is contraindicated and not recommended by practitioners. Conditions listed by the ICTA[6] include: broken bones, dislocations, hernias, bulging discs, organ failure, sunburned or open skin, those undergoing cancer therapies, cupping over the area with a known deep vein thrombosis, liver or kidney illness, cardiopathy (undefined), varicose veins. A few other limitations included pregnant females before their second trimester, avoiding excessive pressure for those using blood thinners, hemophiliacs, high/low blood pressure and diabetics. The majority of these contraindications are in place to prevent worsening of the possible conditions.

While cupping therapy is believed to have similar uses as other modalities, little research to support its clinical use exists. While the majority of literature supports the use of ultrasound, SWD and hot packs for increasing blood flow, other therapeutic interventions such as massage remain questionable in the literature. The majority of the current research available for cupping is qualitative data that lacks support for its physiological effects. Understanding proper treatment times, intensity of application and utilization of cup size is absent in the current literature. By conducting a quantitative research study with the use of cupping therapy, it can demonstrate the efficacy of the treatment.

CHAPTER III: METHODOLOGY AND PROCEDURES

The purpose of this study was to determine the effects of both fire and air vacuum cupping applied at a moderate intensity on skin temperature and blood flow of the tibial artery. As a result, the following research questions were used to guide the study: Does fire cupping applied at moderate intensity increase blood flow through the tibial artery in a healthy population? Does air vacuum cupping applied at moderate intensity increase blood flow through the tibial artery in a healthy population? In comparison, does either fire or air vacuum cupping increase blood flow through the tibial artery more than the other? This chapter focuses on experimental design, population of the study, procedures, and data analysis.

Experimental Design

This study used a pre and posttest experimental design. Baseline surface temperatures and blood flow velocity through the tibial artery were measured with the use of surface thermocouples and diagnostic ultrasound, respectively. The independent variables were fire and air vacuum cupping methods. The dependent variables were surface temperature and blood flow velocity.

Population of the Study

A convenience sample of 20 healthy college aged males from a college setting using the North Dakota State University student email listserv participated. To be included in this study, participants reported being between 18-30 years old and healthy. The exclusion criteria included a history of liver or kidney disease, any form of cardiopathy (dilated cardiomyopathy, chronic atrial fibrillation, previous ventricular tachycardia, etc.), current or previous use of blood thinners, high or low blood pressure, diabetes mellitus, a history of a deep vein thrombosis, peripheral vascular disease or cancer treatment within the last 12 months. Though cardiopathy was undefined by the ICTA[6] in their handbook, subjects with any form of cardiopathy were excluded for this study.

Instruments for Data Collection

A Terason t3200™ Diagnostic Ultrasound (MedCorp, LLC., Tampa, FL) with Aquasonic® 100 ultrasound gel (Parker Laboratories, Inc., Fairfield, NJ) applied to the 15L4 Linear transducer (4.0-15.0 MHz) (MedCorp LLC, Tampa FL) was used to measure blood flow in the tibial artery. Both a Khang-Zhu vacuum cupping set (Beijing Kangda World Medical Appliance Center, Beijing, China) and a Royal Massage 2" glass cups (Royal Massage) were used to administer the treatments. A 16 lead Iso Thermex electrothermometer (Columbus Instruments, Columbus, OH) was used to collect surface temperatures from the surface thermocouples (Physitemp Inc., Clinton, NJ). A Power Systems 6" foam roller (Power Systems, Knoxville, TN) was used to slightly flex the knee during the treatment. Other instruments used to complete this study included a lighter (BIC, Shelton, CT), cotton balls (White Cloud, Bentonville, AR), 70% isopropyl alcohol (P&L Development LLC, Clinton SC), locking hemostat (Beadsmith, Carteret, NJ), fire extinguisher, a water container capable of holding at least 16 fluid ounces, ruler, alcohol wipes and a table.

Procedures

The subjects were instructed to come to the Benson Bunker Fieldhouse room 14 for testing. They were to refrain from exercise at least 24 hours prior to testing. As the participants arrived, they were given a basic demographics and health questionnaire (Appendix A). It was explained to each participant that they would be compensated $20 once the data had been fully collected from their session. Once the study had been explained and all participant questions were answered, the subjects signed the consent form and were randomly assigned into their treatment groups. A number from a random number generator was used to determine their treatment group. Even numbers represented placement into the air vacuum cupping group, while odd numbers represented placement into the fire cupping group.

Once a treatment group was assigned, the subject laid prone on the treatment table. The examiner then determined the subject's dominate leg by observing their answer on the demographics and health questionnaire. A Power Systems 6" foam roller (Power Systems Knoxville, TN) was then placed under the ankle joint to passively flex the knee. Then, diagnostic ultrasound was used to locate structures within the knee. First, the examiner selected the preset under LOWER EXTREMITY and ARTERIAL, and pressed enter. With the use of the COLOR button, a parallelogram appeared on the screen. The examiner then found the tibial artery in a short axis view. The frequency was set to high and the depth to 4cm. The structures that were identified included the tibial artery, tibial vein and tibial nerve. Measurements taken were the depth and diameter of the tibial artery. Once the tibial artery was identified, a mark was made over it with a marker.

Following the marking, the transducer was then rotated counter clockwise to switch to the long axis view. After clicking PW, the transducer was then set in the middle of the tibial artery. The examiner then clicked PW again. Pulse flow/scan began once the screen filled up, followed by pressing the freeze button. The examiner then pressed the VELOCITY button to measure peak flow. For each subject, the examiner used all of the peak measurements to create the TAMAX (time average peak velocity).

Using a ruler, a mark was made 3" distally, along with 3" and 7" proximally from the initial mark on the popliteal fossa to mark the treatment areas. A total of four, 2" cups were used. Distal to the popliteal fossa cup number one was placed between the medial and lateral heads of the gastrocnemius muscle. Proximally, cup number two was placed medially over the semitendinosus and semimembranosus muscles, while cup three was placed laterally over the biceps femoris muscle. Finally cup four was placed centrally between the hamstring muscle groups. Next, the treatment areas were cleaned with an alcohol wipe. Using a skin surface thermistor, skin temperatures were measured for one minute directly over all of the targeted treatment areas. During the treatment, a skin surface thermistor was applied between the 3” distal cup and the mark on the popliteal fossa, as well as centrally between the cups placed at 3” and 7” proximally to measure skin temperature change.

To apply the fire cupping, a table to the right side of the patient contained the following items: a lighter, Royal Massage 2” glass cups, and cotton balls placed in 70% isopropyl alcohol. For safety, a water bucket was placed on the table to extinguish any cotton balls and an extinguisher was present underneath the table for emergencies. Once set up was complete, a cotton ball was taken from the isopropyl alcohol jar using a locking hemostat. The cotton ball was then gently pressed to remove any excess alcohol that could drip on the patient while lit.[15] Next, the lighter was then used to ignite the cotton ball. A new cotton ball was used each time they became approximately 50% black. The examiner then inserted the lit cotton ball into the center of the dome of the 2” diameter cup for a count of 3 seconds and applied the cup from 6” away from the patient. Used cotton balls were deposited in a bucket filled with water. Cups were left on the participant for 15 minutes with time beginning with the placement of the last cup. After the 15 minute treatment, the cups were removed by carefully tilting the cup to one side and slowly pulling the participants skin away from the cup rim until the seal was broken.

To apply vacuum cupping, the air valve of a 2” diameter cup was checked to make sure it was free by pulling the valve. The examiner then attached the cup to the hand pump, centered it directly over the target treatment area mark and applied two full “pumps” to secure the cup to the target tissue. The cups were then left on the participant for 15 minutes with time beginning with the placement of the last cup.[27] After the 15 minute treatment, the cups were removed by carefully tilting the cup to one side and slowly pulling the participants skin away from the cup rim until the seal was broken.

Once the treatment was completed, the examiner then re-measured the skin tissue temperature by taping a skin surface thermocouple over the treatment areas for one minute. Next, blood flow was also re-measured in the tibial artery using the same diagnostic ultrasound parameters as previously stated above beginning with the step of finding the tibial artery in a short axis view. After use, the cups were cleaned using alcohol wipes and left to dry. At the end of the session, ice was available to all of the participants and they were reminded to review their welcome letter with information for proper self-care. This study was approved by the NDSU Institutional Review Board.

Data Analysis

Data collected was analyzed using SPSS version 21 (SPSS Software. 21st edition; IBM, Upper Saddle River, NJ) and an independent T-Test was performed for artery diameter, blood flow, and skin temperature using a level of significance set to $P \leq .05$.

CHAPTER IV: MEASURING TIBIAL ARTERY BLOOD FLOW FOLLOWING A MODERATE FIRE AND AIR VACUUM CUPPING TREATMENT

Abstract

Background: Cupping therapy has become an increasingly popular method of alternative medicine. However, no quantitative measures on the effects of cupping therapy on blood flow and lymphatic drainage have been examined. **Purpose:** The purpose of this study was to determine the effects of both fire and air vacuum cupping applied at a moderate intensity on skin temperature and blood flow of the tibial artery. The research questions that guided this study included: Does either fire cupping or air vacuum cupping applied at moderate intensity increase blood flow through the tibial artery in a healthy population? Does either method of cupping increase blood flow through the tibial artery more than the other? **Study Design:** A pre and posttest experimental design was used. Independent variables included both fire and air vacuum cupping and dependent variables were skin surface temperatures and blood flow velocity. **Methods:** Twenty healthy males (20.70 ± 2.83 years) participated. Blood flow and skin temperatures were measured prior to the intervention. The intervention included either fire or air vacuum cupping for 15 minutes. After the testing period, blood flow and skin temperature were re-measured. **Results:** Blood flow from fire cupping had a range of change from -62.68ml/min to +298.54ml/min. The four surface temperatures during fire cupping increased 0.14°C ± 0.30°C. Blood flow from air vacuum cupping had a range of change from -120.42ml/min to 304.4ml/min. All four surface temperatures during air vacuum cupping did not change. **Conclusions:** The results suggest that air vacuum and fire cupping both increased and decreased blood flow. Furthermore, fire cupping decreased the tibial artery blood flow (-3%) while air vacuum cupping increased (5%). It is possible that the inability to accurately control pressures exerted by fire cupping created more subcutaneous tissue pressure than expected. **Clinical Relevance:** These results suggest air vacuum cupping affects deep tissues (2.35cm ± 0.32cm) more significantly than fire cupping. More research is needed to support or refute the use of cupping therapy for increasing blood flow. **Key Terms:** Fire cupping, Air vacuum cupping, Blood flow, Skin Temperature **What is known:** Currently, there is no literature regarding the relationship between cupping therapy, blood flow and skin temperature. Also, there is no recommendation for what cups fit best over different parts of the body or patient preparation to achieve the best results. **What this study adds to the existing knowledge:** This study adds quantitative data about skin temperature, blood flow, and artery diameter. Also, suggestions can be inferred from the results to best achieve results from patients.

Introduction

As a method of alternative medicine that dates back to the ancient Egyptians and Chinese, cupping therapy has been used to cure colds, chest infections and even gynecological disorders.[1,2] Original cups were created from hollowed out animal horns, bamboo and copper.[2] More recently, cups are created from glass, silicone and other plastics.

To correctly apply cupping therapy, it is vital to be aware of the numerous theories, instruments, and methods that guide its use. The oldest and most well-known method of cupping therapy involves glass cups for the use of fire cupping.[1,3] Fire cupping is a method that utilizes a heat source to increase temperature within the dome of the cup compared to air temperature outside of the cup. The resulting cooling of air within the dome of the cup creates a negative pressure vacuum drawing skin upwards toward dome. An alternative method of cupping that can be used is air vacuum cupping. Air vacuum cupping utilizes a hand pump or soft silicone dome to draw air out from within the cup after application. Dry cupping is a more common technique in western medicine that leaves the dermal layers intact therefore eliminating the risk of infection.[3,4] A few techniques that are used with dry cupping include stationary, gliding and flash cupping.[1] Parameters such as the number of cups, intensity of application and total time of application, are all important factors to a patient's recovery. The ICTA handbook[1] bases its application intensity, cupping technique and treatment length off of age categories.

The mechanical and physiological effects of cupping therapy are not well understood due to the lack of scientific data. Both Yoo and Tausk[3] and Tham et al[5] suggest that the largest cup size that will fit on the targeted anatomical area should be used. Pressures that are exerted both increase and decrease in correlation to cup size. It is also important to note that as tissue depth increases, the normal stresses applied decrease across all cup sizes.[3] The visible circular marks received from the treatment are believed to be ruptured capillary vessels and toxins[3] or stagnant Qi and buildup of biological waste products.[1]

While cupping therapy has never been directly studied before, negative pressure therapy has been supported for the use of post injury and post-surgical edema.[6] Negative pressure therapy is the use of sub atmospheric pressures to achieve subcutaneous soft tissue expansion resulting in accelerated tissue formation.[7] Other effects of negative pressure therapy include increased blood flow, angiogenesis and lymphatic fluid movement.[7,8] It is suggested that negative pressure therapy can influence the movement of interstitial fluids with consistent change in the treatment position.[6] Research suggests that 125mmHg of vacuum strength is appropriate to achieve maximal increase in blood flow in swine models.[7] Swine skin is believed to be an appropriate replacement to human skin for studies performed in vivo due to a lack of difference in mechanical or structural properties.[9]

Cupping therapy uses a negative pressure vacuum over a targeted area to achieve therapeutic effects.[1,3,5] As a result of these effects, the technique is thought to facilitate healing by increasing blood flow and lymphatic drainage,[1] despite limited support in the literature for these claims. Other various theories behind cupping therapy include counter irritation of trigger points, increasing blood and lymphatic flow, and decreasing neural sensitivity.[1,10] Currently cupping therapy is not regulated by the Federal Drug Administration. Two associations that offer courses and certifications in cupping therapy are the International Cupping Therapy Association[11] and ACE Massage & Medicupping.[12] Over 10 domestic and international continuing education regulatory boards exist that recognize the ICTA.[11]

Materials and Methods

A convenience sample of 20 healthy college aged males (20.70 ± 2.83 years) from a college setting participated. To be included in this study, participants reported being between 18-30 years old and healthy. Exclusion criteria included a history of liver or kidney disease, any form of cardiopathy (dilated cardiomyopathy, chronic atrial fibrillation, previous ventricular tachycardia, etc.), current or previous use of blood thinners, high or low blood pressure, diabetes mellitus, a history of a deep vein thrombosis, peripheral vascular disease or cancer treatment within the last 12 months. Though cardiopathy was undefined by the ICTA[1] in their handbook, subjects with any form of cardiopathy were excluded from this study.

The subjects were instructed to refrain from exercise at least 24 hours prior to testing. As the participants arrived, they were given a basic demographics and health questionnaire (Appendix A). Once the study had been explained and all participant questions were answered, the subjects signed the consent form and were randomly assigned into their treatment groups. A number from a random number generator was used to determine their treatment group. Even numbers represented placement into the air vacuum cupping group, while odd numbers represented placement into the fire cupping group.

Once a treatment group was assigned, the subject laid prone on the treatment table. A Power Systems 6” foam roller (Power Systems Knoxville, TN) was placed under the ankle joint to passively flex the knee of the subject’s dominant leg, as determined by the demographics form. After entering the patient information into the diagnostic ultrasound, the examiner selected the lower extremity and arterial preset and set the frequency to high and depth to 4cm. With the use of the COLOR Doppler, the examiner then identified the tibial artery in a short axis view. The structures identified included the tibial artery, tibial vein and tibial nerve. Next, the measurements taken included both the depth and diameter of the tibial artery (Figure 1). The tibial artery was identified and a mark was made on the skin with a marker over the tibial artery area to make repeating measurements at the same location easier after treatment.

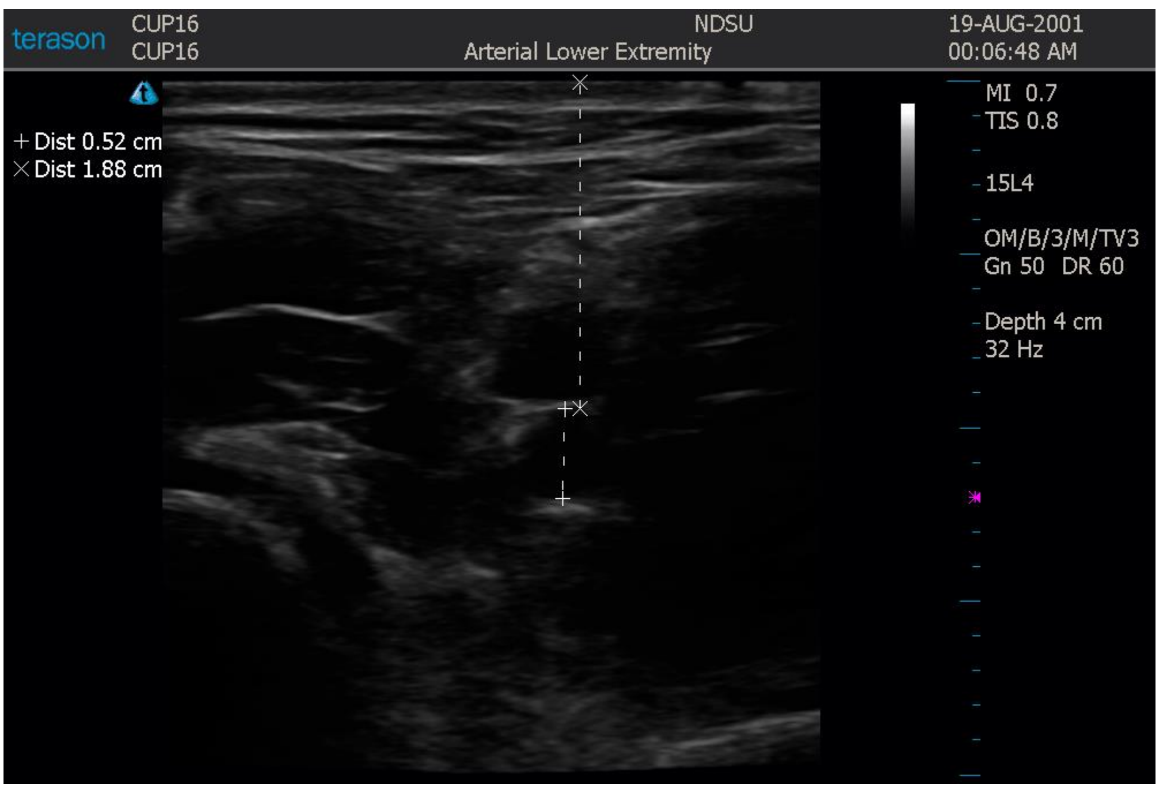

Figure 1. Visual of measuring popliteal artery diameter and depth.

Following the marking, the transducer was rotated counter clockwise to switch to the long axis view. After turning on the pulse wave, the transducer was placed to display the middle of the tibial artery. Then, the examiner clicked pulse wave and the pulse flow/scan began. Once the screen filled with recorded blood flow, the examiner pressed the freeze button to capture the image. Next, the examiner pressed the VELOCITY button to measure peak flow. For each subject, the examiner used all of the peak measurements to create the TAMAX (time average peak velocity).

Using a ruler, a mark was made 3” distally, along with 3” and 7” proximally from the initial mark on the popliteal fossa to mark the treatment areas. A total of four, 2” cups were used. Distal to the popliteal fossa cup number one was placed between the medial and lateral heads of the gastrocnemius muscle. Proximally, cup number two was placed medially over the semitendinosus and semimembranosus muscles, while cup three was placed laterally over the biceps femoris muscle. Finally cup four was placed centrally between the hamstring muscle groups (Figure 2).


(a)

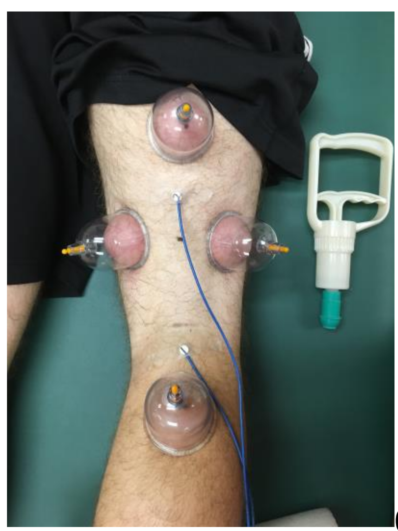
(b)

Figure 2. Application of fire cupping (a), air vacuum (a) cupping and thermocouple placement.

The treatment areas were then cleaned with an alcohol wipe. Using a skin surface thermistor, skin temperatures were measured for one minute directly over all of the targeted treatment areas (Figure 3). During the treatment, a skin surface thermistor was applied between the 3” distal cup and the mark on the popliteal fossa, as well as centrally between the cups placed at 3” and 7” proximally to measure skin temperature change (Figure 2).

Figure 3. Application of thermocouples for measuring skin temperatures.

To apply the fire cupping, a table to the right side of the patient contained the following items: a lighter, Royal Massage 2” glass cups, and cotton balls placed in 70% isopropyl alcohol . For safety, a water bucket was placed on the table to extinguish any cotton balls and an extinguisher was present underneath the table for emergencies. Once set up was complete, a cotton ball was taken from the isopropyl alcohol jar using a locking hemostat. Then, the cotton ball was gently pressed to remove any excess alcohol that could drip on the patient while lit. Next, the cotton ball was lit using the lighter. A new cotton ball was used each time they became approximately 50% black. The examiner then inserted the lit cotton ball into the center of the dome of the 2” diameter cup for a count of 3 seconds and applied the cup from 6” away from the patient. Used cotton balls were deposited in a bucket filled with water. Cups were left on the participant for 15 minutes with time beginning with the placement of the last cup. After the 15-minute treatment, the cups were removed by carefully tilting the cup to one side and slowly pulling the participant's skin away from the cup rim until the seal was broken.

To apply air vacuum cupping, the air valve of a 2" diameter cup was checked to make sure it was free by pulling the valve. The examiner then attached the cup to the hand pump, centered it directly over the target treatment area mark and applied two full "pumps" to secure the cup to the target tissue. The cups were then left on the participant for 15 minutes with time beginning with the placement of the last cup.[1] After the 15 minute treatment, the cups were removed by carefully tilting the cup to one side and slowly pulling the participants skin away from the cup rim until the seal was broken.

In the event of a cup losing its adherence during the treatment, a few steps were followed. If a glass fire cup lost adherence, it was immediately replaced with an unused cup over the original application site with the steps mentioned above. The unused cup was placed rim up to allow the air within the dome of the cup to cool to room temperature. On the other hand, if an air vacuum cup lost adherence, the same cup was reapplied to the original application site using the same steps as mentioned above. Each time a cup lost adherence, the cup was first reapplied to the subject then a tally was made on the results record sheet to count the number of times each individual cup needed to be reapplied.

Once the treatment was completed, the examiner re-measured the skin tissue temperature by taping a skin surface thermocouple over the treatment areas for one minute. Simultaneously, blood flow was re-measured in the tibial artery using the same diagnostic ultrasound parameters as previously stated above beginning with the step of finding the tibial artery in a short axis view. After use, the cups were cleaned using alcohol wipes and left to dry. At the end of the session, ice was available to all of the participants and they were reminded to review their welcome letter with information for proper self-care (Appendix B). This study was approved by the University's Institutional Review Board.

Data Analysis

Descriptive statistics were performed for age, dominant leg, artery diameter, cup reapplications, and leg girth. Data collected was analyzed using SPSS version 21 (SPSS Software. 21st edition; IBM, Upper Saddle River, NJ) and an independent T-Test was performed for artery diameter, blood flow, and skin temperature using a level of significance set to $P \leq .05$.

Results

A total of 20 subjects were recruited for participation in this study. Two subjects from the fire cupping group were removed from the results due to the inability for cups two and three to remain adhered to the skin. For these subjects, girth measurements at 3" proximal averaged 36.55 ± 1.2cm as opposed to the study average of 42.4 ± 4.53cm. Another subject from the fire cupping group and a subject from the air vacuum cupping group were removed due to being a statistical outlier. As a result, a total of 16 subjects (7 fire cupping, 9 air vacuum cupping) with an average age of 20.53 ± 3.02 years were included in the final statistical calculations.

The T1 skin thermocouple temperature increased 0.54°C ± 0.55°C for air vacuum cupping, and 0.43°C± 0.85°C for fire cupping in a pre/posttest comparison. The T2 skin temperature increased 0.53°C ± 0.84°C for air vacuum cupping, and 0.56°C± 1.56°C for fire cupping in a pre/posttest comparison. The T3 skin temperature increased 0.60°C ± 1.16°C for air vacuum cupping, and 0.45°C± 0.87°C for fire cupping in a pre/posttest comparison. The T4 skin temperature decreased -0.12°C ± 0.17°C for air vacuum cupping, and -0.06°C± 1.6°C for fire cupping in a pre/posttest comparison. For all skin temperatures, the temperature changes were not statistically different between the two treatment groups. Skin thermocouple 1, t(9.683) = .296, p = .773 , skin thermocouple 2, t(8.668) = -.046, p = .965, skin thermocouple 3, t(13.996) = .297, p = .771, skin thermocouple 4, t(7.272) = .114, p = .912 (Table 1).

Table 1. The change in skin temperature at each thermocouple in a pre/posttest comparison.

	Thermocouple 1	Thermocouple 2	Thermocouple 3	Thermocouple 4
Air Vacuum Cupping	0.54°C ± 0.55°C	0.53°C ± 0.84°C	0.6°C ± 1.16°C	-0.12°C ± 0.17°C
Fire Cupping	0.43°C± 0.85°C	0.56°C± 1.56°C	0.45°C± 0.87°C	-0.06°C± 1.6°C

During the cupping treatment, skin temperatures changed 0.58°C ± 0.45°C at T1 for air vacuum cupping and 1.00°C ± .5°C for fire cupping. For site T2, air vacuum cupping increased 0.30°C ± 0.44°C and 0.17°C ± 0.26°C for fire cupping. Skin temperatures during the cupping treatment were not considered statistically different between the treatment groups t(12.204) = -1.726, p = .109 and t(13.220) = .702, p = .495 for temperatures at thermocouple 1 and thermocouple 2, respectively. Skin thermocouple temperatures during testing can be located within Table 2.

Table 2. The skin temperature change during treatment.

	Thermocouple 1	Thermocouple 2
Air Vacuum Cupping	0.58°C ± 0.45°C	0.30°C ± 0.44°C
Fire Cupping	1.00°C± 0.50°C	0.17°C± .26°C

Cup number 1 for air vacuum cupping was reapplied an average of 8.22 ± 7.58 times, compared to 3.14 ± 2.61 times for fire cupping. Cup number 2 was reapplied an average of 5.89 ± 6.13 times compared to 2.29 ± 2.87 times for fire cupping. Cup number 3 was reapplied 10.78 ± 8.04 times, compared to 3.57 ± 3.10 times for fire cupping. Cup number 4 was reapplied 4.44 ±

5.32 times, compared to 0.86 ± 1.07 times for fire cupping (Table 3). The average calf girth at 3" distal, and 3" and 7" proximal were 35.56 ± 2.78cm, 43.66 ± 4.12cm, and 54.84±5.48cm, respectively.

Table 3. The number of times each cup was reapplied to the skin and the girth measurements at the corresponding locations.

	Cup 1	Cup 2	Cup3	Cup 4
Air Vacuum Cupping	8.22 ± 7.58	5.89 ± 6.13	10.78 ± 8.04	4.44 ± 5.32
Fire Cupping	3.14 ± 2.61	2.29 ± 2.87	3.57 ± 3.10	.86 ± 1.07
Girth Measurements- Air Vacuum (Cm)	35.12 ± 2.44	42.51 ± 2.51	Same as Cup 2	53.3 ± 4.10
Girth Measurements- Fire (Cm)	36.11 ± 3.28	45.17 ± 5.40	Same as Cup 2	56.81 ±6.71
Girth Measurements- Combined (Cm)	35.56 ± 2.78	43.68 ± 4.11	Same as Cup 2	54.84 ± 5.50

Blood flow during air vacuum cupping increased 48.78 ± 122.36ml/min. However, blood flow decreased -23.33 ± 154.17ml/min during fire cupping. In comparison, blood flow in the tibial artery after fire and air vacuum cupping were not statistically different, $t(11.29) = 1.014$, $p = .332$.

Discussion

In a pre/posttest comparison, results for skin temperatures for thermocouples T1-T4 support that that the mean difference in skin temperature was not statistically, nor clinically significant. However, tissue temperatures taken during the testing located between the mark on the popliteal fossa and cup number one (3" distal of the popliteal fossa) increased 1.00°C ± .5°C for fire cupping (Figure 2b). This suggests that skin tissue temperature rise was clinically, but not statistically significant. To be considered clinically significant, a minimum temperature increase of 1°C was necessary to achieve.[13] It is possible that due to its proximity to a superficial artery, skin thermocouple one during the treatment saw an increased tissue temperature from indirect blood flow influence from cup number one. With the influence of a negative pressure vacuum just distal to the thermocouple, it could be assumed that superficial capillaries experienced vasodilation and therefore increased blood flow.

These results are comparable to other studies regarding massage techniques.[14-16] However they are unlike other therapeutic modalities believed to increase blood flow and skin temperature.[17-23] Our study results are comparable to those of Sefton et al[14] who after performing massage on 13 defined zones, only saw a tissue temperature increase between 0.4°C to 0.8°C. However, our study results varied from those found in the Portillo-Soto et al[23] study where it was determined that massage increased leg tissue temperature by 1.77°C over the control group. A number of explanations could account for the variability in study results. Primarily it is worth noting that in our study, cups were applied in stationary positions throughout the 15-minute treatment. In comparison, while Portillo-Soto et al[23] did not report the type of strokes performed during their massage protocol, it can be assumed that friction from skin to skin contact during the massage could account for a portion, if not the majority, of the increase in skin temperature. Also, when comparing massage protocols, it is worthwhile to mention that Sefton et al[14] performed massage therapy on the chest, upper back, neck and anterior/posterior sides of the arms and hands. On the other hand, Portillo-Soto et al[23] only performed massage therapy on the posterior calf. As a result of the limited area that Portillo-Soto et al performed massage therapy on, it is plausible that the tissues were more affected by the protocol. Likewise, it is possible that in our study the treatment time, number of cup reapplications, or number of cups used affected the results of our study.

Interestingly, T4 had the lowest number of cup reapplications and decreased in skin temperature as compared to all other treatment sites. It is possible that a moderate pressure applied during a cupping treatment (and minimally disrupted) creates excessive compression around the rim of the cup.[5] The excessive compression may collapse the capillary vessels and disrupt blood flow to the local area, resulting in a tissue temperature decrease. This theory is observed between the difference in air vacuum and fire cupping skin temperatures and cup reapplications (Tables 1 and 3). The cups with the lower number of reapplications had lower temperature changes than those with higher cup reapplications (Tables 1 and 3). Without the ability to use thermocouples to measure skin temperature directly over the treatment site during the cupping application, conclusions cannot be drawn as to the result of skin temperature fluctuations during the treatment beneath the cups.

Statistical results from blood flow suggest that air vacuum cupping increases blood flow 48.78 ± 122.36ml/min, while fire cupping decreases blood flow -23.33 ± 154.17ml/min through the tibial artery (Table 4). Though increases were observed for air vacuum cupping, they were not statistically different than that of fire cupping, $t(11.29) = 1.014$, $p = .332$. However, the results have clinical significance. Primarily, the standard deviation value for air vacuum cupping is closer to the mean blood flow (SD is approximately 2.54 times the mean) than that of fire cupping (SD is approximately 6.7 times the mean). This suggests that the results for blood flow following air vacuum cupping treatments are more consistent than those of fire cupping. Also, as a result of even the slightest increase in vasodilation, excretion of cellular waste and distribution of hormones and nutrients will take place.[24] This clearing of cellular debris and moderation of hormones and nutrients will influence the body's healing processes and provide the optimal environment for regeneration of tissues and other vital functions to take place. No recommendation for an optimal value of increased blood flow for healing exists. Therefore, any increase in blood flow should be considered clinically significant. Due to the frequency that air vacuum cups lost adherence, and despite an increase in tibial artery blood flow, inconsistent negative pressures may not have been able to expand capillaries adequately to achieve a maximal increase in blood flow. Additionally, application on a more anatomically flat area would provide more consistency in cup adherence and therefore result in consistent measurements.

Table 4. Blood flow pre and posttest, and mean differences.

	Pre test	Posttest	Pre/Post mean differences Mean ± SD
Air Vacuum Cupping	872.13 ± 193.57	920.91 ± 273.34	47.78 ± 122.36
Fire Cupping	853.11 ± 291.49	829.78 ± 208.66	-23.33 ± 154.17

A number of possibilities could serve as an explanation for fire cupping decreasing blood flow. Cup adherence and pressures exerted from the technique are just a few. Unlike air vacuum cupping, control over the pressures exerted from fire cupping cannot be adjusted to achieve the exact pressures desired. This inability to precisely control pressures exerted adds to the possibility that fire cups create more of a negative pressure vacuum than air vacuum cupping when performed as described in the methods. Coupled with the limited amount of times that fire cups were reapplied (Table 3), the negative pressures might have overcome capillary pressure and caused temporary collapse of the capillaries preventing blood flow to local tissues.

In comparison to other methods of increasing blood flow, cupping therapy is both similar in some aspects, and different in others. Similar to our study, Fabrizio et al[25] measured blood flow in the tibial artery while Baker et al[26] used a cardiograph applied to the calf. After performing a 1MHz ultrasound at 1.0 and 1.5 W/cm^2 for 5 minutes, the authors[25] reported a 13% increase in blood flow. Baker et al[26] reported an increase in blood flow after using ultrasound alone or after an ice pack was applied before ultrasound. However, they failed to mention the exact values that blood flow increased. While Baker[26] and Fabrizio[25] either measured blood flow in the calf or tibial artery, neither method of collection was the same as our study. Fabrizio et al[25] did not mention a formula that was used to determine the blood flow in the tibial artery. Comparatively, results from our study suggest that air vacuum cupping increased tibial artery blood flow by 5% while fire cupping decreased it -3%. These results imply that in contrast of applying therapeutic ultrasound[25] and cupping therapy, therapeutic ultrasound is more for effective at increasing blood flow at the depth of the tibial artery.

A major difference between our study and others[25,26] when looking at blood flow is the mechanical action of the various therapies to achieve their effects. While cupping therapy uses negative pressure[1] to create sub atmospheric pressures and allows for subcutaneous expansion, therapeutic ultrasound uses high frequency acoustic vibrations to create molecular vibrations which then generates a thermal effect.

The researchers noted a number of limitations with our study. Primarily, the limited number of subjects could have resulted in the increased standard deviations beyond the mean values of blood flow velocity. Furthermore, the experience level of the evaluating researcher is worthy of noting. Due to the limited clinical experience of the evaluating researcher with diagnostic ultrasound and blood flow velocity software, reliability of the results are possibly more varied than would be with an experienced sonographer. Also, it was observed that some subjects swiftly began the study shortly after arriving and others took time to change or sign paperwork etc. This variability in activity level between subjects could account for some inconsistency in the results based on movement and vasodilation from previous walking and other activities of daily living. In the future, this limitation could be negated by requiring all participants to perform a 15-minute “cool down” by having them lay on the treatment table to stabilize blood flow before beginning the study.

Likewise, previous fitness levels and anatomic variability are possible when considering influences. Individuals who are of better cardiovascular fitness who have an increased cardiovascular ejection fraction and cardiovascular output could result in outliers in comparison to the general population. For instance, individuals who participated in a walk-jog-run protocol at 70% of their maximal heart rate, for one hour, four days a week saw a 20% increase in left ventricular mass by the end of the study.[27] As a result of this increased ventricular mass, concentric cardiovascular strength of the left ventricle will be improved resulting in increased cardiovascular output and ejection fraction.[28] Furthermore, high intensity interval training has been found to increase left ventricular ejection fraction as much as 35%.[29] Overall, this means that anyone who is physically active beyond a basic activities of daily living is more likely to have an increased ejection fraction and cardiac output than someone who is sedentary. Since a certain activity level was not specified in the participant exclusion criteria, cardiovascular conditioning may have played a role in the outcome of the results.

Furthermore, those who have anatomically larger tibial arteries could influence results due to the limited number of subjects. Consequently, the formula to calculate TAMAX (time averaged peak velocity) relies heavily upon the diameter measurement of the subject’s tibial artery. Therefore, with limited available subjects, any inaccuracy in this measurement would magnify the blood flow in ml/min vastly. For example, if two individuals who had tibial artery diameters of .55cm and .60cm and had the exact same TAMAX value of 30cm/s, their overall blood flow would be 427.43ml/min and 508.68ml/min, respectively. Therefore, those who have anatomically larger tibial arteries could cause a shift in statistical results (Table 5).

Table 5. Artery diameter and correlated blood flow in a pre/posttest comparison.

Subject number-Testing group	Artery Diameter-Pretest (Cm)	Artery Diameter-Posttest (Cm)	Pretest blood flow (ml/min)	Posttest blood flow (ml/min)
1- Air	.55	.5	638.87	518.45
8- Air	.60	.59	1107.86	996.46
9- Air	.62	.63	982.15	1284.55
11-Air	.51	.51	567.27	505.16
13-Air	.58	.57	816.00	804.00
14-Air	.65	.65	913.6	1125.73
18-Air	.62	.67	1031.94	1172.89
19-Air	.56	.59	874.47	967.66
20-Air	.63	.69	1125.34	1272.58
3-Fire	.51	.56	513.55	812.09
5-Fire	.51	.53	817.76	769.69
6-Fire	.55	.53	907.57	844.89
10-Fire	.56	.51	898.06	975.84
12-Fire	.67	.62	1189.80	1172.89
15-Fire	.61	.63	1209.30	1203.7
17-Fire	.57	.57	764.02	789.62

One thing to note is the use of TAMAX for blood flow calculation versus TAMEAN (time averaged mean velocity) could account for variability in the results.[30] While TAMAX measures the peak velocity of each individual cardiac cycle, TAMEAN is used to represent the average flow over a cardiac cycle.[30] Since the TAMAX is inherently a larger value than the TAMEAN, results will naturally be a larger in value. Due to the limitations of software, TAMEAN was not used for calculation of blood flow for our study. Therefore, this could account for variability in the results and more importantly explain the increased size of the standard deviations.

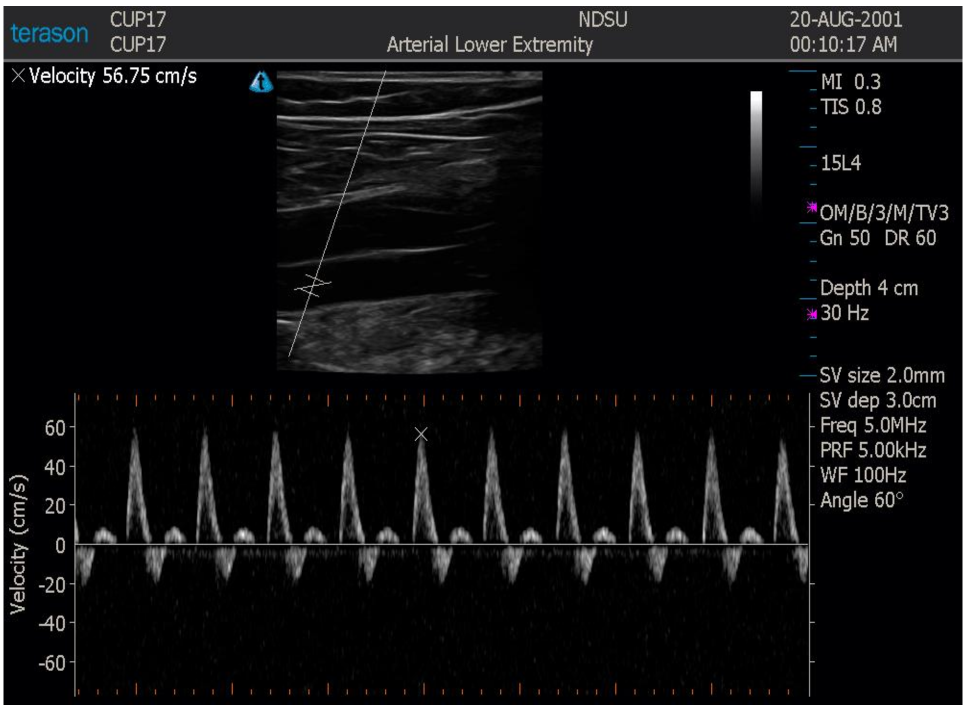

Figure 4. Visual of data collection for TAMAX.

A number of other limitations that were noted during the study. Warm cups or distance the cup was lit from the patient were factors that were challenging to mitigate or mimic consistently. Cups that had been previously used to perform the fire cupping treatment had to be switched out after losing suction with the skin. The reason for this is that the glass creating the dome of the cup was still warmer than that of the surrounding air. This resulted in heat transfer between the glass and air within the dome of the cup causing a loss of suction strength due to the lack of air vacuum if the same cup was reapplied. Additionally the weight of the fire cups also played a roll in the number of times they lost vacuum strength with the skin. Towels were placed under cups two and three to best prevent the cups from falling off the skin due to gravity. No towels were placed around cups one and four. Lighter cups would be advisable for a follow up study.

Body hair, which was not identified as a main concern of the study, became a factor in the results of this study. Individuals with an increased amount of hair on their legs tended to have cups lose air vacuum strength more often. Though participants for this study were not asked to shave their legs, the ICTA[1] recommends individuals undergoing cupping therapy to not shave within four hours of treatment. Future studies should have patients shave at least four hours prior to testing. Another limitation that was noted during testing was leg size. At 3" proximal to the popliteal fossa, two of the three smallest girth measurements were (36.55 ± 1.2cm) unable to support 2" glass cups and therefore removed from the testing results. Using the tibial artery might be considered a limitation because of the depth. More superficial arteries may be necessary to determine the superficial effect of cupping.

Lastly, location of the targeted treatment areas in relationship to the tibial artery where blood flow measurements were taken is worth noting. It is feasible that as a result of more cups being applied proximally to the tibial artery than distally, a lack of negative pressure was created distally to influence blood flow through the tibial artery. This methodological flaw could account for some variability in the results.

Conclusion

In conclusion, the results of this study suggest that either fire or air vacuum cupping are not suitable for the purposes of achieving increased skin temperature and blood flow through the tibial artery. In the case of fire cupping, a decrease in blood flow may be achieved when applying the cupping technique as described in the methods section, therefore clinical discretion is advised as to the purpose and goal for the treatment. Because silicone cups were not studied, the effectiveness of these cups is not notable from the results of this study. Additionally, the use of cupping therapy for the purpose of increasing lymphatic drainage, myofascial release, increasing flexibility, range of motion and pain relief were all not studied and therefore would require testing before determining the effectiveness for treatment. As a result of being the only quantitative study on cupping therapy, further research is necessary to determine the effectiveness of cupping therapy for the purpose of increasing skin temperature and blood flow.

References

1. Association ICT. Contemporary Cupping Methods. In. Kent, WA2006.
2. Shannon AJ. The Art of Massage Cupping Therapy. *Massage Magazine.* 2004(110):54-62.
3. Yoo SS, Tausk F. Cupping: East meets West. *Int J Dermatol.* 2004;43(9):664-665.
4. Kravetz RE. Cupping glass. *Am J Gastroenterol.* 2004;99(8):1418.
5. Tham LM, Lee HP, Lu C. Cupping: From a biomechanical perspective. *Journal of Biomechanics.* 2006;39(12):2183-2193.
6. Iivarinen JT, Korhonen RK, Jurvelin JS. Modeling of interstitial fluid movement in soft tissue under negative pressure--relevance to treatment of tissue swelling. *Computer Methods In Biomechanics And Biomedical Engineering.* 2016;19(10):1089-1098.
7. Morykwas MJP, Faler BJB, Pearce DJB, Argenta LCM. Effects of Varying Levels of Subatmospheric Pressure on the Rate of Granulation Tissue Formation in Experimental Wounds in Swine. In. Vol 47(5): Annals of Plastic Surgery; November 2001:547-551.
8. Cipolla J, Baillie DR, Steinberg SM, et al. Negative pressure wound therapy: Unusual and innovative applications. *OPUS.* 2008;12:15-29.
9. Żak M, Kuropka P, Kobielarz M, Dudek A, Kaleta-Kuratewicz K, Szotek S. *Determination of the mechanical properties of the skin of pig foetuses with respect to its structure.* Vol 132011.

10. Kouskoukis CE, Leider M. Cupping. The art and the value. *The American Journal Of Dermatopathology.* 1983;5(3):235-239.
11. Association ICT. Cupping Therapy. 2005; https://www.cuppingtherapy.org. Accessed August-December 2016.
12. ACE Massage Cupping and Medicupping. 2017; https://massagecupping.com, October 2016.
13. Knight KL, Draper DO. *Therapeutic Modalities: The Art and Science.* 2 ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2013.
14. Sefton JM, Yarar C, Berry JW, Pascoe DD. Therapeutic massage of the neck and shoulders produces changes in peripheral blood flow when assessed with dynamic infrared thermography. *J Altern Complement Med.* 2010;16(7):723-732.
15. Wiltshire EV, Poitras V, Pak M, Hong T, Rayner J, Tschakovsky ME. Massage impairs postexercise muscle blood flow and "lactic acid" removal. *Medicine And Science In Sports And Exercise.* 2010;42(6):1062-1071.
16. Brummitt J. The role of massage in sports performance and rehabilitation: current evidence and future direction. *N Am J Sports Phys Ther.* 2008;3(1):7-21.
17. Strand K. *Measuring Brachial Artery Flow Following a 3MHz, 1. 0 W/Cm^2 Thermal Therapeutic Ultrasound Treatment*: Department of Health, Nutrition and Exercise Science, North Dakota State University; 2015.
18. Draper DO, Hawkes AR, Johnson AW, Diede MT, Rigby JH. Muscle heating with Megapulse II shortwave diathermy and ReBound diathermy. *Journal Of Athletic Training.* 2013;48(4):477-482.
19. Draper DO, Harris ST, Schulthies S, Durrant E, Knight KL, Ricard M. Hot-Pack and 1-MHz Ultrasound Treatments Have an Additive Effect on Muscle Temperature Increase. *J Athl Train.* 1998;33(1):21-24.
20. Garrett CL, Draper DO, Knight KL. Heat distribution in the lower leg from pulsed short-wave diathermy and ultrasound treatments. *J Athl Train.* 2000;35(1):50-55.
21. Petrofsky JS, Laymon M. Heat transfer to deep tissue: the effect of body fat and heating modality. *J Med Eng Technol.* 2009;33(5):337-348.
22. Hawkes AR, Draper DO, Johnson AW, Diede MT, Rigby JH. Heating capacity of rebound shortwave diathermy and moist hot packs at superficial depths. *J Athl Train.* 2013;48(4):471-476.
23. Portillo-Soto A, Eberman LE, Demchak TJ, Peebles C. Comparison of blood flow changes with soft tissue mobilization and massage therapy. *J Altern Complement Med.* 2014;20(12):932-936.
24. Wilkerson GB. Inflammation in connective tissue: etiology and management. *Athletic Training.* 1985;20(4):298-301.
25. Fabrizio PA, Schmidt JA, Clemente FR, Lankiewicz LA, Levine ZA. Acute effects of therapeutic ultrasound delivered at varying parameters on the blood flow velocity in a muscular distribution artery. *J Orthop Sports Phys Ther.* 1996;24(5):294-302.
26. Baker RJ, Bell GW. The effect of therapeutic modalities on blood flow in the human calf. *J Orthop Sports Phys Ther.* 1991;13(1):23-27.
27. DeMaria An Fau - Neumann A, Neumann A Fau - Lee G, Lee G Fau - Fowler W, Fowler W Fau - Mason DT, Mason DT. Alterations in ventricular mass and performance induced by exercise training in man evaluated by echocardiography. (0009-7322 (Print)).

28. Platt C, Houstis N, Rosenzweig A. Using exercise to measure and modify cardiac function. (1932-7420 (Electronic)).
29. Wisloff U, Stoylen A Fau - Loennechen JP, Loennechen Jp Fau - Bruvold M, et al. Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients: a randomized study. (1524-4539 (Electronic)).
30. Blanco P. Volumetric blood flow measurement using Doppler ultrasound: concerns about the technique. *Journal of Ultrasound.* 2015;18(2):201-204.

REFERENCES

1. Reinke JM, Sorg H. Wound repair and regeneration. *Eur Surg Res.* 2012;49(1):35-43.
2. Greaves NS, Ashcroft KJ, Baguneid M, Bayat A. Current understanding of molecular and cellular mechanisms in fibroplasia and angiogenesis during acute wound healing. *J Dermatol Sci.* 2013;72(3):206-217.
3. Wilkerson GB. Inflammation in connective tissue: etiology and management. *Athletic Training.* 1985;20(4):298-301.
4. Ward PA, Lentsch AB. The acute inflammatory response and its regulation. *Archives Of Surgery (Chicago, Ill: 1960).* 1999;134(6):666-669.
5. Knight KL, Draper DO. *Therapeutic Modalities: The Art and Science.* 2 ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2013.
6. Association ICT. Contemporary Cupping Methods. In. Kent, WA 2006.
7. Shannon AJ. The Art of Massage Cupping Therapy. *Massage Magazine.* 2004(110):54-62.
8. Lauche R, Cramer H Fau - Hohmann C, Hohmann C Fau - Choi K-E, et al. The effect of traditional cupping on pain and mechanical thresholds in patients with chronic nonspecific neck pain: a randomised controlled pilot study. (1741-4288 (Electronic)).
9. Iivarinen JT, Korhonen RK, Jurvelin JS. Modeling of interstitial fluid movement in soft tissue under negative pressure--relevance to treatment of tissue swelling. *Computer Methods In Biomechanics And Biomedical Engineering.* 2016;19(10):1089-1098.
10. Cipolla J, Baillie DR, Steinberg SM, et al. Negative pressure wound therapy: Unusual and innovative applications. *OPUS.* 2008;12:15-29.
11. Morykwas MJP, Faler BJB, Pearce DJB, Argenta LCM. Effects of Varying Levels of Subatmospheric Pressure on the Rate of Granulation Tissue Formation in Experimental Wounds in Swine. In. Vol 47(5): Annals of Plastic Surgery; November 2001:547-551.
12. Żak M, Kuropka P, Kobielarz M, Dudek A, Kaleta-Kuratewicz K, Szotek S. *Determination of the mechanical properties of the skin of pig foetuses with respect to its structure.* Vol 132011.
13. Sefton JM, Yarar C, Berry JW, Pascoe DD. Therapeutic massage of the neck and shoulders produces changes in peripheral blood flow when assessed with dynamic infrared thermography. *J Altern Complement Med.* 2010;16(7):723-732.
14. Yoo SS, Tausk F. Cupping: East meets West. *Int J Dermatol.* 2004;43(9):664-665.
15. Rozenfeld E, Kalichman L. New is the well-forgotten old: The use of dry cupping in musculoskeletal medicine. (1532-9283 (Electronic)).
16. Martini F, Timmons M, Tallitsch R. Human Anatomy. In. 7 ed: Pearson Education Inc.; 2 012:53 50-541.
17. Joao De Masi EC, Campos AC, Joao De Masi FD, Ratti MA, Ike IS, Joao De Masi RD. The influence of growth factors on skin wound healing in rats. *Braz J Otorhinolaryngol.* 2016;82(5):512-521.
18. Baker RJ, Bell GW. The effect of therapeutic modalities on blood flow in the human calf. *J Orthop Sports Phys Ther.* 1991;13(1):23-27.
19. Fabrizio PA, Schmidt JA, Clemente FR, Lankiewicz LA, Levine ZA. Acute effects of therapeutic ultrasound delivered at varying parameters on the blood flow velocity in a muscular distribution artery. *J Orthop Sports Phys Ther.* 1996;24(5):294-302.

20. Morishita K, Karasuno H, Yokoi Y, et al. Effects of Therapeutic Ultrasound on Intramuscular Blood Circulation and Oxygen Dynamics. *Journal of the Japanese Physical Therapy Association.* 2014;17(1):1-7.
21. Shoemaker JK, Pozeg ZI, Hughson RL. Forearm blood flow by Doppler ultrasound during rest and exercise: tests of day-to-day repeatability. / Caracterisation du flux sanguin au niveau des avant bras par doppler a ultrasons pendant la periode d ' exercice physique ou de repos: tests de repetitivite journaliers. *Medicine & Science in Sports & Exercise.* 1996;28(9):1144-1149.
22. Strand K. *Measuring Brachial Artery Flow Following a 3MHz, 1. 0 W/Cm^2 Thermal Therapeutic Ultrasound Treatment*: Department of Health, Nutrition and Exercise Science, North Dakota State University; 2015.
23. Hovind H, Nielsen SL. Changes in subcutaneous and muscle blood flow after short-wave diathermy. *Bibliotheca Anatomica.* 1973;11:417-422.
24. Goats GC. Continuous short-wave (radio-frequency) diathermy. *Br J Sports Med.* 1989;23(2):123-127.
25. Garrett CL, Draper DO, Knight KL. Heat distribution in the lower leg from pulsed short-wave diathermy and ultrasound treatments. *J Athl Train.* 2000;35(1):50-55.
26. Brown M, Baker RD. Effect of pulsed short wave diathermy on skeletal muscle injury in rabbits. *Phys Ther.* 1987;67(2):208-214.
27. Hovind H, Nielsen SL. Local blood flow after short-wave diathermy: preliminary report. *Archives Of Physical Medicine And Rehabilitation.* 1974;55(5):217-221.
28. Draper DO, Hawkes AR, Johnson AW, Diede MT, Rigby JH. Muscle heating with Megapulse II shortwave diathermy and ReBound diathermy. *Journal Of Athletic Training.* 2013;48(4):477-482.
29. Al-Mandeel MM, Watson T. The thermal and nonthermal effects of high and low doses of pulsed short wave therapy (PSWT). *Physiother Res Int.* 2010;15(4):199-211.
30. Hawkes AR, Draper DO, Johnson AW, Diede MT, Rigby JH. Heating capacity of rebound shortwave diathermy and moist hot packs at superficial depths. *J Athl Train.* 2013;48(4):471-476.
31. Petrofsky JS, Laymon M. Heat transfer to deep tissue: the effect of body fat and heating modality. *J Med Eng Technol.* 2009;33(5):337-348.
32. Okada K, Yamaguchi T, Minowa K, Inoue N. The influence of hot pack therapy on the blood flow in masseter muscles. *J Oral Rehabil.* 2005;32(7):480-486.
33. Draper DO, Harris ST, Schulthies S, Durrant E, Knight KL, Ricard M. Hot-Pack and 1-MHz Ultrasound Treatments Have an Additive Effect on Muscle Temperature Increase. *J Athl Train.* 1998;33(1):21-24.
34. Mori H, Ohsawa H, Tanaka TH, Taniwaki E, Leisman G, Nishijo K. Effect of massage on blood flow and muscle fatigue following isometric lumbar exercise. *Med Sci Monit.* 2004;10(5):Cr173-178.
35. Portillo-Soto A, Eberman LE, Demchak TJ, Peebles C. Comparison of blood flow changes with soft tissue mobilization and massage therapy. *J Altern Complement Med.* 2014;20(12):932-936.
36. Wiltshire EV, Poitras V, Pak M, Hong T, Rayner J, Tschakovsky ME. Massage impairs postexercise muscle blood flow and "lactic acid" removal. *Medicine And Science In Sports And Exercise.* 2010;42(6):1062-1071.

37. Brummitt J. The role of massage in sports performance and rehabilitation: current evidence and future direction. *N Am J Sports Phys Ther.* 2008;3(1):7-21.
38. Kouskoukis CE, Leider M. Cupping. The art and the value. *The American Journal Of Dermatopathology.* 1983;5(3):235-239.
39. Association ICT. Cupping Therapy. 2005; https://www.cuppingtherapy.org. Accessed August-December 2016.
40. ACE Massage Cupping and Medicupping. 2017; https://massagecupping.com, October 2016.
41. Tham LM, Lee HP, Lu C. Cupping: From a biomechanical perspective. *Journal of Biomechanics.* 2006;39(12):2183-2193.
42. Kravetz RE. Cupping glass. *Am J Gastroenterol.* 2004;99(8):1418.
43. Morton S. In:Oral communication, July 10th - 12th 2015.
44. Hendriks FM, Brokken D, Oomens CWJ, Bader DL, Baaijens FPT. The relative contributions of different skin layers to the mechanical behavior of human skin in vivo using suction experiments. *Medical Engineering and Physics.*28(3):259-266.

APPENDIX A: DEMOGRAPHICS AND HEALTH QUESTIONAIRE

Name:______________________________ Date:__________________________

Gender (circle one): M F Age: __________________________

If you were to kick a soccer ball, which leg would it be with? (circle one):

L R

Have you ever received Cupping Therapy before? (circle one):

Y N

If yes, when was your last session?:_______________________________________

Do you have current or a previous history of liver or kidney disease? (circle one):

Y N

If yes, what disease were you diagnosed with?:_____________________________

Have you ever been diagnosed with a cardiopathy (disease of or deformation to the heart)? (circle one):

Y N

If yes, what disease or deformation?:______________________________________

Have you previously or do you currently use prescription blood thinners? (circle one):

Y N

If yes, what is the medication name?:______________________________________

Have you ever been diagnosed with high or low blood pressure? (circle one):

Y N

Have you ever been diagnosed with diabetes mellitus? (circle one):

Y N

Do you have history of deep vein thrombosis (blood clots)? (circle one):

Y N

Do you have a history of peripheral vascular disease? (circle one):

Y N

Have you undergone any treatments for cancer within the last 12 months? (circle one):

Y N

APPENDIX B: PRE PARTICIPATION AND SELF CARE LETTER

Dear participant,

Thank you for confirming your appointment for the cupping therapy study. Before you arrive for the session, I would like to remind you of a few self care guidelines for your safety and healing once you are done. These guidelines are as follows:

BEFORE you come:

No exercise for 24 hours prior to the study

You should not be sunburnt on the lower extremity.

Make sure you come to the session well hydrated and not hungry.

Food/beverage information: You should avoid caffeine, alcohol, sugary foods and drinks, dairy, processed meats. Consume an abundance of clean water.

AFTER you leave:

Markings can disappear as quick as a few hours or as long as 2-3 weeks.

You should not aggressively exfoliate over the treatment site.

Things to avoid after treatment include: cold/wet/windy weather conditions, hot showers, baths, saunas, hot tubs and aggressive exercise for 4-6 hours.

Food/beverage information: should avoid caffeine, alcohol, sugary foods and drinks, dairy, processed meats. Consume an abundance of clean water.

Potential effects

-Your body's immune system can temporarily react to this release in toxins as if it were the flu. Some side effects you may experience are nausea, headache. With rest and increased water intake, these effects will subside.

PLEASE be sure to bring/wear shorts for the study.

If you have any questions regarding the study or any self-care guidelines, please feel free to contact me. Thank you!

-Michael Hilliard