ACUTE EFFECTS OF SOUND ASSISTED SOFT TISSUE MOBILIZATION (SASTM) ON LOWER EXTREMITY FLEXIBILITY, ISOKINETIC AND ISOMETRIC STRENGTH

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SASTM™ is a myofascial technique used to mobilize soft tissue and aid in the elongation of soft tissue and create physiological change. The purpose of the study was to determine the acute effects of Sound Assisted Soft Tissue Mobilization (SASTM™) on lower extremity hamstring strength (isokinetic & isometric) and flexibility. Thirty division III male athletes with limited ROM of ≤ 90° of knee extension with 90° of hip flexion while lying supine consented to volunteer. Each subject was treated and measured through a double-blinded experimental design where the subjects and tester were unaware of the real treatment being administered and measured. The research consisted of 4 visits (familiarization/baseline, and 3 data collection session). Testing sessions were conducted a week after the baseline session, followed by two sessions, 2 days and a week after the 1st session. Three different modalities (SASTM™, Therapeutic Ultrasound and "The Stick") were performed on a treatment leg, and the opposite leg served as a control. Data collection consisted of a warm-up on a cycle ergometer followed by one randomly chosen modality on the treatment leg. Data collection was conducted using a Cybex 300-isokinetic device and a digital goniometer. Isokinetic strength testing was performed at 60, 180 and 240°/s. Isometric testing was collected at 45° of knee flexion. Repeated two-way ANOVA's (3-Treatment x 3-Time) were used for statistical analyses to determine the effects of interventions and the time on strength and flexibility. The statistical analyses resulted in no significant results ($p \leq .05$) for acute

effects for either strength or flexibility with respect to time, treatment or treatment and time interactions.

Rafael E. Bahamonde, PhD., Chair

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LIST OF ABBREVIATIONS AND ACRONYMS

ACL	Anterior Cruciate Ligament
AROM	Active ROM
ASTYM®	Augmented Soft Tissue Mobilization
GRASTON®	GRASTON® myofascial massage technique
IASTM	Instrument Assisted Soft Tissue Mobilization
“J” Stroke	Method of directional massage in a shape of a “J”
ROM	Range of Motion
SASTM™	Sound Assisted Soft Tissue Mobilization
STM	Soft Tissue Mobilization
TM	Trade Marked
Fibroplasia	Formation of Scar Tissue
Prone	Lying face down
Supine	Lying face up
Lateral Epicondyle	Boney prominence on the outside of elbow
Lateral Malleolus	Boney prominence on the outside of ankle
Greater Trochanter	Boney prominence on the outside of hip

CHAPTER ONE: INTRODUCTION

1.1. Introduction

Soft tissue mobilization (STM) is a manual technique used by therapists to manipulate and mobilize scar tissue within soft tissue.[1-2] The theory behind manual therapy is to mobilize fibroblast materials and create microtrauma while allowing the body to continue to physiologically change.[3] Soft tissue mobilization techniques were introduced to aid in the breakdown of myofascial adhesions post injury and/or any physical activity. The overarching problem for decrease in ROM is production of myofascial adhesions during the fibroblastic repair phase in the healing process. During this process, the body begins depositing fibroblasts to heal any gaps within muscle and/or skin tissue. [4] Several other techniques exist which uses a variety of instruments to mobilize muscle fibers. This effect can cause muscle deactivation, ROM deficits as well as elasticity and extensibility problems in muscles, ligaments, and tendons.

The focus of this research project was the use of three techniques (SASTM™, ultrasound and "The Stick") to determine if acute ROM and/or strength could be increased post treatment with any or all of these methods. The first method is Augmented Soft Tissue Mobilization, ASTYM® which uses a series of molded instruments to mobilize muscle fibers to aid in fibroblastic production and alignment.[5-6] The tools are shaped for ease of treatment with the contours of the human body so maximum amount of contact can be achieved. The second method is the GRASTON® technique. The technique utilizes eight different stainless steel tools shaped to contour for easy gliding and contact over the greatest amount of surface area. [10-12]

The third method is Sound Assisted STM, SASTM™. This technique uses tools similar to ASTYM® and GRASTON® but creates sound that both participant and clinician can hear during treatment to identify problem areas.[13] The sound heard with this technique comes from manual "scraping" of the tissue that is related to adipose tissue, adhesions and muscle fibers. This sound has been described anecdotally as a "crunching" sound heard occurring during the treatment. The tools are shaped to promote effective contact between the tissue and tool while involving 4 different motions. 1 treatment motion is distal to proximal followed by a 2nd proximal to distal motion. The last 3rd and 4th motions are called transverse and the "J" stroke.[13] The clinician should transition from larger to smaller tools when performing this technique.[13] The smaller tools are used when focal portions of scar tissue are detected. The overall goal for each STM technique is the mobilization of scar tissue/fibroblastic materials.[4,5,14,15]

Research has shown a number of associated benefits with flexibility including athletic performance, reduced injury risk, prevention or reduction of post exercise soreness, and improved coordination.[20] STM consists of effleurage, pettrisage, and shaking led to increased ROM. Research studies have explained that instrumented STM clinically improved ROM in participants and found significant improvements in ROM after seven weeks of STM.[17] Post studies show immobilization due to injury decreases the extensibility of tissue due to loss of extensible collagen, but some type of STM has been beneficial for increased ROM.[17-20]

1.2 Statement of Purpose

STM techniques are widely used by clinicians to treat patient dysfunction. However, little scientific evidence exists related to acute changes on healthy participants..

Therefore, the purpose of this research is to find if SASTM™ may be effective for increasing acute strength and flexibility on healthy participants.

1.3 Hypotheses

The following research hypotheses were used to guide this research:

- SASTM™ when administered to participants will increase in isokinetic strength.
- SASTM™ when administered to participants will increase in increase isometric strength.
- SASTM™ when administered to participants will increase in hamstring flexibility.
- SASTM™ when compared to ultrasound and The Stick will produce more significant positive difference

1.4 Delimitations

1. Thirty participants (N=30) were used in this research study
2. The use of only three methods of treatment ("The Stick", SASTM™, Ultrasound)
3. The use of participants who have not had an injury in the last 6 weeks or currently do not have an injury to the hamstrings region.

1.5 Limitations

1. All participants were recruited on a volunteer basis.
2. Participants were only tested using flexibility, isokinetic and isometric strength.
3. Participants were not monitored for physical activity between testing

1.6 Assumptions

1. The participants were representatives of the general population for out of season Division III college athletes.
2. The participants were able to perform a maximal effort during the isokinetic testing

1.7 Definitions of Terms

1. Augmented STM (ASTYM®): This technique is used on participants to reduce scar and unhealthy tissue that has a known injury or ailment. The technique aids the physiological response in muscles, ligaments and tendons, which aid in healthy movement of extremities and joints. This technique explains it resolves a participants' scar tissue problem and not just relieve symptoms. http://www.astym.com/Main
2. Sound Assisted Soft Tissue Mobilization (SASTM^{TM}): This technique uses specialized ergonomic tools (See Figure 1) to locate, loosen and break down myofascial restrictions. Sound is use as a medium to locate and treat specific areas of scar tissue. The technique uses controlled microtrauma to stimulate an inflammatory process. Microtrauma from SASTM^{TM} initiates a process that aids the body to absorb old scar tissue and restarts fibroplasia for healing. This process results in remodeling of muscles, ligament, and tendons. (www.sastm.com). SASTM^{TM} technique is used for reducing scar tissue, increasing mobility and decreasing swelling.

Figure 1: Sound Assisted Soft Tissue Mobilization Tools

3. Fibroplasia: Formation of scar tissue
4. Supine Position: Position of participant lying on their back (See Figure 2)

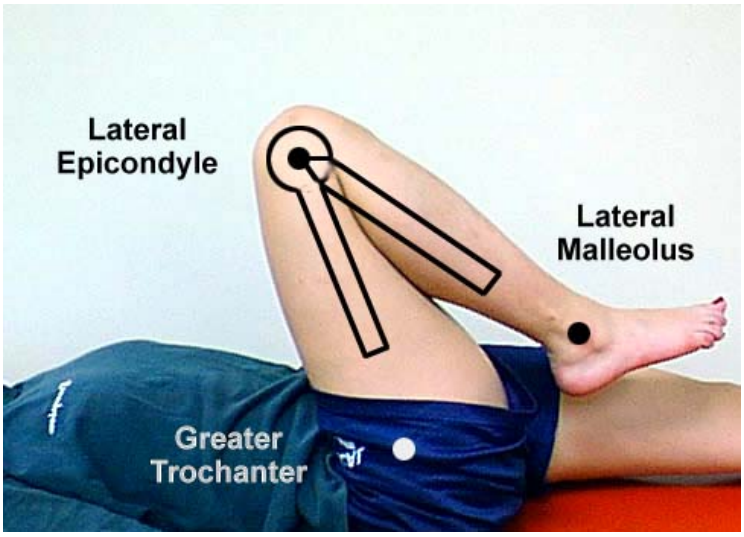

Figure 2: Supine Position

5. GRASTON®: An innovative, patented form of IASTM. It enables clinicians to effectively break down scar tissue and fascial restrictions. The technique utilizes specially designed stainless steel instruments to specifically detect and effectively

treat areas exhibiting soft tissue fibrosis or chronic inflammation. (http://www.grastontechnique.com/)

6. Hudl Application: Video goniometer to measure joint angles (See Figure 3).

Figure 3: Hudl IPad Application (Lincoln, NE)

7. Soft Tissue Mobilization (STM): Massage technique to mobilize tissue, decrease pain, increase mobility, decrease scar tissue, and increase efficiency of muscle.
8. Cybex 300 Isokinetic Machine (Lifetime Fitness, Rosemont, Ill) (Figure 4): Isokinetic machine that objectively measures torque exerted by a participant during flexion and extension of the knee. For this research, the machine will measure torque exerted by the hamstring to measure isometric strength as well as isokinetic at 60, 180 and 240$^{o/s}$.

Figure 4: Cybex 300 Isokinetic Machine

9. Therapeutic Ultrasound Machine (TUM) (Figure 5) (Chattanooga Inc., in Chattanooga, TN): The machine uses electrical energy and through deformation of a crystal change in electrical polarity in the ultrasound head then producing acoustic energy. This energy is transmitted into participants to help with molecular collision and heat generation in the body for a deep heating mechanism. TUM was used to produce heat into the tissue treated to see its effect on the hamstring musculoskeletal region for this research. This specific machine of TUM has been chosen due to convenience in our human performance lab for use and has been established as a therapy machine and to generate effects in a way to be useful to participants.[68]

Figure 5: Chattanooga Ultrasound Machine

CHAPTER TWO: REVIEW OF LITERATURE

The literature presents many different perspectives on IASTM, how strength and ROM play a part with the healing of the body, and different abnormalities treated with STM. This review looked scientifically into the several different ways that STM have effects on the human body. The majority of the research is focused on the GRASTON® and ASTYM® techniques with limited amount of research on SASTM™. Research studies seem to support all forms of STM and how STM helps the body heal after injury and increase ROM through some physiological effects. [2,3,17,21,22] Increasing flexibility and strength may support the use of these techniques regardless if an injury is present. Research review shows a connection of soft tissue mobilization to a term called mechanotherapy. Mechanotherapy uses mechanical pressure or forces to aid in stimulating signals of change at the molecular, cellular, and tissue level.[59] Common stimuli of mechanotherapy is derived from tension, shear force, fluid shearing, pressure change, pushing or pulling forces. These forces are similar to those caused through instrument assisted soft tissue mobilization (IASTM).[59]

Mechanotransduction is the process by which a biophysical pressure causes a cellular and molecular change through conversion of a mechanical pressure.[59] This conversion is called biochemical coupling, an outside mechanical pressure causes a biochemical response in the human body.[59] It has been identified that most musculoskeletal injuries have a hard time regenerating, resulting in scar tissue being presented which causes an inferior tissue with negative mechanical, functional and physiologic properties.[59] Some literature suggests IASTM is a form mechano-therapy.[60] This form of therapy can be compared to those effects similar to IASTM.

Over 100 million musculoskeletal disorders effect adults in the US per year with an 87% clinician usage of some type of manual therapy for treatment. These treatments are mechanical in nature and may cause some type of physiological healing.[60] Mechanotherapy produces significant changes in fibroblastic involvement as a result of increasing pressure and has been shown to increase ROM after 1-5 treatments.[60] This literature review supports how pressure change can alter the healing process in given injury area through mechanotherapy.[60]

A similar study, using mechanotherapy measured jump height, peak power and peak velocity for strength after treatment. The results of this article speak to pressure consistency as well as sequencing of the treatment which are items to focus on for future research.[61] MacDonald explained the physiological effects created with the resorption of fibrosis and inducing regeneration of collagen and noted that IASTM could not be supported as the defining factor for muscular performance.[61]

Foam rolling is performed as a form of myofascial mobilization. The effect of both IASTM and foam rolling on the hamstring and quadriceps ROM were investigated on 20 male soccer players. Results showed both techniques significantly improved knee and hip range of motion.[62] Use of the foam roller was similar to the use of "The Stick" in our study.[62] Markovic showed a 10-11% increase in range of motion between the knee and the hip.[62]

2.1 GRASTON® Review

Stow presented the GRASTON® technique, a form of IASTM, provided an optimal environment for healing by creating healthy inflammation, altering muscle spasms, and aid in normal muscle function.[23] This form of massage was necessary to

promote proper healing and the alignment of collagen fibers within a muscle and tendon.[23] Muscle restrictions were possibly related to a decrease in ROM after an injury or due to excessive use.

Donahue's research examined EMG analysis of vastus lateralis, rectus femoris, and vastus medialis and as well as measure force production and muscle activation.[24] Donahue found increases in force production after the first day and every day after each treatment was performed for an average of 6 treatments of STM.[24] Significant muscle activation was found between testing days for the vastus medialis and vastus lateralis.[24-26] Based on these results STM decreased scar tissue and increased muscle force production.[24,27] He also found that bruising itself during the treatment more than likely desensitized the skin allowing for an effective treatment to occur considering the amount of pressure needed to treat a participant with STM.[24]

Loghmani and Warden researched the effects of the GRASTON® technique on rats medial collateral ligaments (MCL after being surgically disabled.)[28] The GRASTON® technique accelerated the formation of collagen fibers which created a stronger medial collateral ligament than the control group which were found to be significant.[28] Loghmani suggested the goal of GRASTON® was to restore mobilization of soft tissue which, aided the rats to produce more collagen and allowed for a stronger ligament after treatment. [28]

Clinical case studies have shown such cases as a 42-year-old male diagnosed with trigger thumb was treated with the GRASTON® technique® and found to be successful. Success was measured as the patient reporting decrease pain and increase ROM so an

increase function could be noticed.[33] Howitt, et al. found the same results during conservative treatment on grade one tibialis posterior strains.[32]

Crothers et al. studied the effects of the GRASTON® technique on a non-specific thoracic spine pain.[36] They measured the effects solely on pain level of the participant and found after the initial treatment and then at 3, 6, and 12 months afterwards participants had a decrease pain level. Results were compared to the initial treatment and a control group.[36]

2.2 Hamstring and Soft Tissue Mobilization

The hamstring muscles were included into the literature search to see if evidence of STM altered the muscle mobilization enough to allow for an increase of ROM and/or strength. Increased ROM may come from breakdown of possible adhesions, increasing blood flow to specific areas for increase function or the stimulation of mechanoreceptors within the muscle through pressure.

The hamstrings are a commonly injured muscle group with the rate of injury depending on many factors not limited to flexibility, health, age, activity level, etc. Lysholm and Wiklander found in runners the injury rate per 1000 hours was different for middle distance, sprinters, and long distance runners. [1] Specifically the authors found that in long distance runners the rate or injury was approximately 2.5 per 1000 hours while middle distance runners and sprinters were approximately 5.6 to 5.8 per 1000 hours.[1]

Research has found football hamstring injuries were linked to contributing factors such as age and previous injuries. In a sample size of 306 football players the rate was

1.1 hamstring injuries per year with a contributing factor of age such the older a participant was the more susceptible they were to an injury.[37]

STM has been used for quite some time to help with hamstring treatment, ROM and myofascial release. The benefits of STM are connected to increase ROM, decrease pain in the hamstrings and decrease fibrotic tissue.[40] Huang et al. found if a clinician focuses on the musculotendinous region of the hamstring they could induce a greater ROM.[40] By performing no massage, ten second and thirty second massages on the hamstring and measuring hip flexion with a goniometer found differences in hip flexion between pre and posttests of 5.9% and 7.2% respectively for both ten and thirty seconds.[40] Van den Tillaar stated that insufficient ROM caused by poor muscle flexibility may be a cause of muscle strains and increased risk of injury.[41] Barlow stated the following, when muscles are allowed sufficient time to accelerate limb segments, connective tissues are spared and are therefore less prone to rupture. [42]

Hopper et al., examined the effects of two different massages (dynamic STM such as GRASTON® and classic massage such as petrissage and effleurage) techniques on hamstring lengthening.[43] Passive straight leg raises were used to evaluate the hamstring flexibility at both baseline and after each treatment. A significant improvement in lengthening immediately after the treatment was found in both groups, but no long term comparison was measured to see future effects.[43] It was concluded that both techniques and presumably other massaging techniques would benefit hamstring flexibility.[43] Hopper et al. evaluated and treated forty-five males who volunteered for a randomized, controlled single blind design to study STM on hamstring flexibility .[43] The control group was instructed to position themselves prone for five minutes and other group

treated with a dynamic STM.[43,44] Hamstring flexibility was calculated after taking the entire ROM of hip flexion against pelvis rotation.[43] The dynamic STM showed a significant increase in flexibility with respect to the control group.[43]

The literature review revealed supportive evidence, assertive statements supporting and non-conclusive evidence with regard to the use of STM..[43,46] The research found a focus on injuries on the achilles tendon in rats.[4,5] The literature clearly supported the use of STM on areas of the body with flexibility problems due to fibroblastic adhesions.[4,5,46] Current literature lacked information when it came to using STM for the prevention of injury although the benefits from treatment are just as beneficial. In total research found STM can increase flexibility, extensibility, and in some cases strength in a muscle group or extremity.[20,41,47] Loghmani and Warden explain with respect to a medial collateral ligament that the research showed a 43.1% increase in tensile strength, 39.7% increase in stiffness and had the ability to absorb 57.1% more energy of force than the control medial collateral ligament.[69]

Certain relationships, such as number of treatments performed before good outcomes were noticed averaged 4-5 treatments. The most common average in the literature was two treatments.[49] The use of passive stretching, positive outcomes for pain and ROM no matter what body part or muscle group were very common practice.[10,50,51] Overall, the findings did show a majority of literature supporting STM to aid in increasing flexibility, extensibility, strength when noted, and decrease pain when used properly and efficiently.[20,41,43]

2.3 Review of ASTYM®

Several research studies have shown the positive effects of ASTYM® in the treatment of injuries or conditions. McCormack found that through the use of ASTYM® on a mid-portion Achilles tendinopathy, a 56 year old recreational tennis player reported a 75% increase in function after six weeks of treatment and reported to be pain free after ten treatments.[52] In another study from McCormack, a 41-year-old participant with bilateral high hamstring tendinopathy, improved 95% after 16 treatments with ASTYM®. The participant reported being able to walk two to five miles after the eighth treatment and able to jog one mile before the onset of pain after 12 visits.[53] Slaven found similar results in a participant with a significant ankle injury after five treatments with ASTYM®. The participant was able to go up and down stairs and run for 40 minutes without pain.[54] Gehlsen et al. used ASTYM® in an animal (rat) model (Achilles tendons) to determine if and how pressure affects a treatment and fibroblast recruitment.[4,5] Harvested Achilles tendons were studied and a significant difference between the control and surgical group, with the deep pressure treatment were found.[4,5] Gehlsen et al. explained that the ASTYM® technique created a microtrauma that promoted healing and healthy inflammation.[4,5] The use of heavy pressure promoted more healing than lighter pressures.[38]

Sevier, et al. reported that by the use of ASTYM® clinicians begin to see results due to treating the underlying problems which aids in eliminating the true cause of soft tissue restrictions and inefficiencies.[7] Sevier believed the underlying problem is not the strain, sprain or tightness of the soft tissues but the scar tissue resisting ROM post injury

or continuous physical activity. It has been stated that an increased change of collagen synthesis can occur by eliminating the main cause of an infliction with ASTYM®.[9,55,56]

In a study by Davies, ASTYM® was effective in decreasing swelling and increasing range of motion post mastectomy in a breast cancer participant.[57] The focus was one 44 year old patient. Improvements were seen post one week of treatments which lasted from 10-15 minutes. The participant had an increase of ROM with their neck, less pain, and ability to grasp a seatbelt from across their body.[57] The swelling volume in her chest had decreased from 1926ml to 1564ml as well as left shoulder flexion ROM increasing from 145 to 159 degrees.[57]

2.4 Review of SASTM™

Due to a limited amount of research found in the literature review, SASTM™ has shown to be similar to IASTM techniques such as GRASTON® and ASTYM®. Research has not been extensive with the time frame this specific IASTM technique has been on the market. Similarity comes with techniques used for each STM and tools outside of physical make up. This technique continues to be researched and considering its nature as an IASTM we will consider previous research related to GRASTON® and ASTYM® as well as SASTM™. The SASTM™ technique mimics that of its competitor's buts adds the sound component that both the clinician and participant can and/or should hear. The premise behind the sound as it dissipates and breaks down the scar tissue, the sounds should be decreasing as treatments are increasing.

Research studies supporting SASTM™ are limited but therapy continues to be supported by research articles focusing on the overall healing process, effects of massage

on blood flow, and instrument assisted soft tissue mobilization. This technique falls under such a category of IASTM.

CHAPTER THREE: METHODOLOGY

3.1 Participants

Thirty males (N=30) from Manchester University ranging from 18 to 23 years of age were recruited for the study. Participants were out of season, division III male athletes, with a lack of ROM of $\leq 90^{o}$ of knee extension with 90^{o} of hip flexion while lying in a supine position with no pressure but participant movement. A participant was excluded if he had a current injury or has had an injury to the lower extremity in the last 6 months. Once IRB approval was received, the research group was recruited through use of flyers, emails, and word of mouth. Informed consent was obtained before any participant was released to participate in the study.

3.2 Experimental Design

A double-blind design with a two way repeated measures ANOVA, treatment and time, were used to evaluate the research hypotheses. Sample size determination test (G-Power) with power set at 0.8 and a significance level of $p \leq 0.05$ revealed that a minimum of 30 participants were needed for this research. As a double-blind design, neither the tester nor participant knew what treatment was being received and researched overall.

The variables in this study were:

1. Independent Variable(s): Treatment Modalities (SASTM^{TM}, "The Stick" and Therapeutic Ultrasound) & Time (Baseline, Acute and 2 Days).
2. Dependent Variables(s): Isokinetic torque (60, 180 and $240^{o/s}$), Isometric Torque @ 45^{o} and ROM (hamstring flexibility)

The treatment techniques for this research were SASTM™ (treatment 1), manual massage with "The Stick" (treatment 2), and Therapeutic Ultrasound (treatment 3) as well as a control leg with no treatment. Participants were not aware SASTM™ was the treatment method being assessed. Each participant was instructed three different methods are used as pre-competition preparation, therefore the participants were not aware what method was being tested.[58] A flowchart below details the methodology (See Figure 6).

Prior to any testing, each participant was taken through a familiarization period for each treatment and testing protocol. Each participant performed 10 min warm-up of stationary biking at 5 MPH followed by initial baseline measurements of muscle strength and flexibility. Further testing outcomes performed five repetitions of maximal knee flexion on an isokinetic Cybex 300 machine each at 60, 180 and $240^{o/s}$. To test hamstring torque, each participant performed five isometric repetitions each for 5s at a fixed 45^{o} of knee flexion followed by a 10s rest. After isokinetic and isometric strength testing, the hamstrings flexibility was assessed using the Hudl video application with built in goniometry. Participants wore spandex shorts or pants for measurements with stickers on the lateral knee joint line, greater trochanter and lateral malleolus. To measure hamstring flexibility the participants were supine with 90^{o} of hip flexion and then asked to extend the lower leg (below the knee) to their max capacity to determine hamstring flexibility. The participant was responsible for maintaining this for at least 2s on their own for video to be recorded.

Once baseline testing was finished, each participant was tested receiving one of the three treatment modalities. For each participant, the legs were randomly assigned to a control or treatment leg, followed by a drawing to determine the order of treatments. The

treatment legs were SASTM™, “The Stick” or therapeutic ultrasound. A control leg was used to see if any change could or would occur to compare to other techniques and baseline measures. Immediately following the treatment the participant was measured for ROM, isokinetic and isometric strength. Two days later, participants were measured again with the same procedures. One week later participants repeated the blind draws to determine which treatment or control was used from those not chosen during treatment one. Measurements were taken using the same treatment procedure.

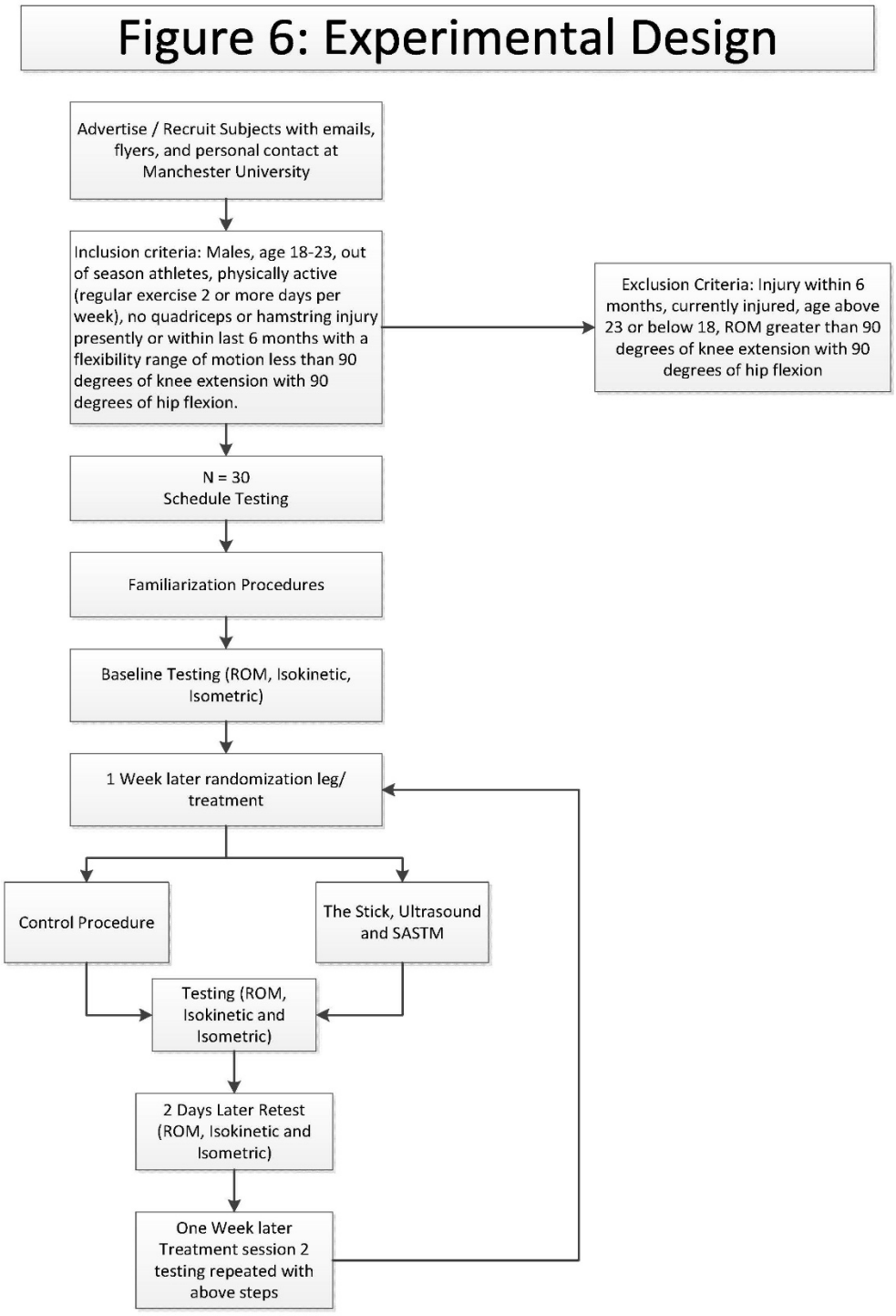

Figure 6: Protocol Flowchart

3.3 Equipment

3.3.1 Chattanooga Ultrasound Unit

The Chattanooga Intelect Ultrasound Unit (Chattanooga Vectra, Chattanooga, TN) is a stand along unit that has the capabilities of producing sound waves to aid in the production of tissue heat. In this device, the electrical energy is converted from positively charged energy into a negatively charged energy. The repeated conversion of energy from positive to negative and back performs a deformation of a quartz crystal called the Piezoelectric Effect. The deformation of the crystal changes electrical energy into sound waves that are then transmitted to the body. Ultrasound waves can create deep or superficial heat into muscles and joints. The deep heat and pressure change of ultrasound increases the blood flow to the area treated. This pressure change can be from direct contact pressure or internal pressure change to alter cellular response. The two versions of this are cavitation and microstreaming. Cavitation is the pressure change of a cell with the expansion and contraction of the cells. This change can result in an increase in cellular permeability which allows for a more optimal environment for healing. Microstreaming is the spinning of the fluid around cells with acoustic waves being produced by the ultrasound unit. These two versions occur without the collision of molecules to generate change with no heat in a desired treatment area. This increase in fluid and healthy blood brings nutrients and carries away waste. This helps promote healing in injured or unhealthy environments.[68]

3.3.2 SASTM™

SASTM™ was founded in Indianapolis, Indiana by David Graston. SASTM™ (Figure 1) is a set of tools used for myofascial massaging of muscles. These tools are

comprised of a hard polymer plastic with blade like edges that are ergonomically designed for ease of use by users as well as for gliding across muscle and skin. A complete set is comprised of eight tools, each one with a different purpose. Each tool is designed for small to larger based muscles. The larger tools are used to aid in the evaluation of fibroblastic material that may be present in muscle tissue. The tools are used to feel and hear for restrictions during the scanning phase (first session). The smaller tools are used to focus treatments in areas of restrictions once found by larger tools. The tools do this by producing a "crunching" sound when ran over muscle tissue with significant fibroblastic materials present.

3.3.3 "The Stick"

"The Stick" (RPI, Atlanta, GA) (Figure 7) is a non-motorized device used for manual massage therapy. Each roller is made of a plastic material which rolls as the participant moves the device over the extremity. Each participant used "The Stick" to roll over the muscle belly of the hamstring muscles. The participants were asked to bend the knee approximately 90^{o} while sitting. Participants used "The Stick" for a time frame as opposed to 6-8 short daily treatments per "The Stick" website.

Figure 7: "The Stick"

3.3.4 Cybex 300

The Cybex 300 (CSMI Solutions, Stoughton, MA) (Figure 4) is an isokinetic machine which is a specialized exercise testing machine that produces a constant speed no matter how much effort. These machines control the angular velocity of an exercise by stabilizing resistance at a fixed speed throughout a ROM. The Cybex 300 can measure force production for different muscles depending on the extremity tested. The machine has the capabilities of measuring three different fixed speeds (60, 180 & $240^{o/s}$). It consists of two chairs typically with a movable dynamometer in the middle with computer attached. The dynamometer is the portion that consists of a movable arm in which the extremity moves. This portion can be set to fixed speeds as mentioned and at no movement for isometric testing. The computer attached uses a software system called HUMAC for measuring and analyzing force production and ROM data.

3.4 Procedures: Modalities

3.4.1 "The Stick"

The period for this manual massage was 5 min individually on the hamstring muscle group. This manual massage period was chosen by the primary investigator of the research and is not related to the manufacturer. . No significant research supported the use of 5 minutes for this study. This time frame was chosen to be similar to other treatments being performed on each participant. Mikesky et al. did use a two minute protocol in their research to determine acute effects in strength, power and flexibility when using "The Stick".[58] According to the manufacturer, a thirty seconds bout can improve flexibility.[58] Although this research did not show significance with acute effects.[58] In this research the participant rolled the device with moderate pressure from

proximal to distal and distal to proximal, covering the surface area of the muscle being massaged. The focus was a consistent massage over the hamstring muscle groups for at minimum 5 minutes.

3.4.2 SASTM™

Each participant had one treatment of SASTM™ (Figure 1) performed on a randomly selected leg that include 4 strokes from distal to proximal, proximal to distal, and medial to lateral. Each session was delivered with a medium pressure to every participant. Time was not used to quantify a treatment rather the selection of strokes and certified clinician training to be consistent between treatments. Each tool has a specific "blade" depending on the technique used and how extreme the condition. Post treatment the participants were immediately measured for flexibility. Participants were informed to engage any activities they wished as the treatment should not affect their regular activities of daily living and exercise.

3.4.3 Chattanooga Ultrasound Unit (Figure 5)

Each participant was treated therapeutically with an ultrasound device. During this procedure, the participant received a continuous 100%, 1.0 MHz treatment at a Beam Non-Uniformity Ratio (BNR) of 5:1 for 5 min to produce acoustic energy into the tissue to attempt to produce heat. The participant received this treatment over the hamstring musculature. Each participant had water-based gel applied to the extremity as a normal medium to increase the condition of the ultrasound treatment. The investigator used circular motions and slight pressure to massage the area with the ultrasound head for 5 min. The protocol used should increase tissue temperature by 2-3 degrees Celsius. Ultrasound was discontinued if feeling of warmth was too extreme or painful.

3.4.4 Cybex 300

The participants were seated on the Cybex 300 machine with one leg strapped down to the chair as well as a shoulder harness for support. Once the participant was strapped in, he was informed that four practice sessions were to be done to familiarize him with the motion and resistance. The speeds used for the isokinetic section of testing were 60, 180 and $240^{o/s}$. Each participant performed four practice repetitions, followed by the five test repetitions for each of the speeds no matter what treatment was performed on either leg. The investigator reminded the participant that maximal effort had to be performed for good results. Once finished, the participant's knee was put into 45^{o} of flexion and was asked to give maximal isometric effort for flexion of the knee. Once the participant finished with one leg, they switched sides and had the opposite leg tested using the same procedures.

3.5 Procedures: Variables

3.5.1 Muscle Flexibility

Each participant was instructed to lie in a supine position and flex his hip to 90^{o} followed by extending only the lower leg (below the knee) to see if knee extension was between 90^{o} and 180^{o} degrees of extension on the goniometer. The participant was instructed to hold hip flexion at 90^{o} for at least 2s for recording. Participants were responsible for holding their own legs to maintain this degree of hip flexion. The measurements were recorded using the Hudl IPad application and a built in goniometer was used to measure hip flexion and knee extension ROM.

3.5.2 Muscular Strength

Each participant went through a familiarization period on the Cybex 300 isokinetic torque device before baseline testing. Familiarization was performed one week before initial baseline testing. The familiarization period was used for each participant to become comfortable with the testing protocol. Each participant that volunteered performed baseline testing to measure the strength of the hamstring muscle group.

The evaluator described to the participant the process and the importance of giving maximal effort to ensure accurate results. The participant was encouraged by the researcher during the testing procedure to aid in maximal effort. The participant went through a series of four repetitions at 60, 180 and $240^{o/s}$ to get a feeling for the movement and resistance. The participant was instructed to give 100% effort into flexing the knee against the resistance provided by the machine for five repetitions with 10s of rest in between. The same protocol was carried out for the bilateral side so comparisons can be measured between both legs. Similarly each participant was asked to give a maximal effort during an isometric contraction at 45^{o} of knee flexion.

3.6 Statistical Analysis

Two way repeated measures [3 (treatments) x 3 (times)] ANOVA statistical analyses were used to evaluate the research hypotheses. The treatment factor levels were ultrasound, "The Stick" and SASTM^{TM} and time factor levels were baseline, acute and 2 days after measurements. A p level ≤ 0.05 was used for all analyses. Dependent variables were ROM, isokinetic (60,180, $240^{0/s}$) and isometric strength. In addition, T-tests were used to compare baseline and control measures. T-tests were used to determine

if baseline and control data were significant enough to use separately or if non-significant to use one or the other to simplify statistical design.

CHAPTER FOUR: RESULTS

4.1 T-Test

In order to determine possible difference between the baseline and control measure and simplify the statistical analyses, paired T-tests (Baseline-control) were performed for each of the dependent variables; isokinetic testing at 60, 180 and 240$^{o/s}$ (See Figure 8), isometric testing (See Figure 9), and ROM (See Figure 10). There were no significant differences found between baseline and control for all dependent variables. No significant ($p \leq .05$) results were found for any of the three isokinetic speeds or isometric test (See Figure 8). Since no significant differences were found between baseline and control data, it was decided to use data from baseline for the remainder of the statistical analyses.

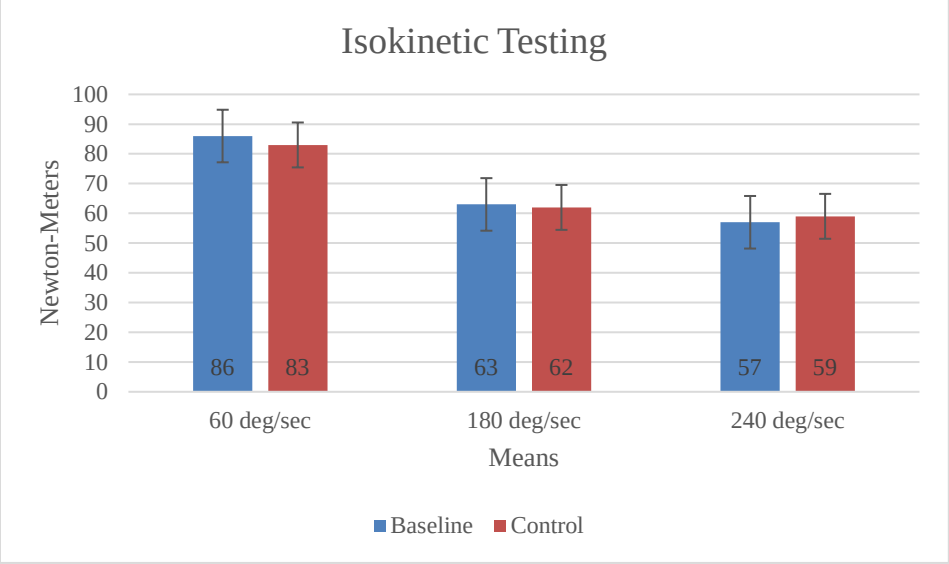

Figure 8: Paired T Test Baseline vs Control (Isokinetic 60$^{o/s}$180$^{o/s}$240$^{o/s}$)

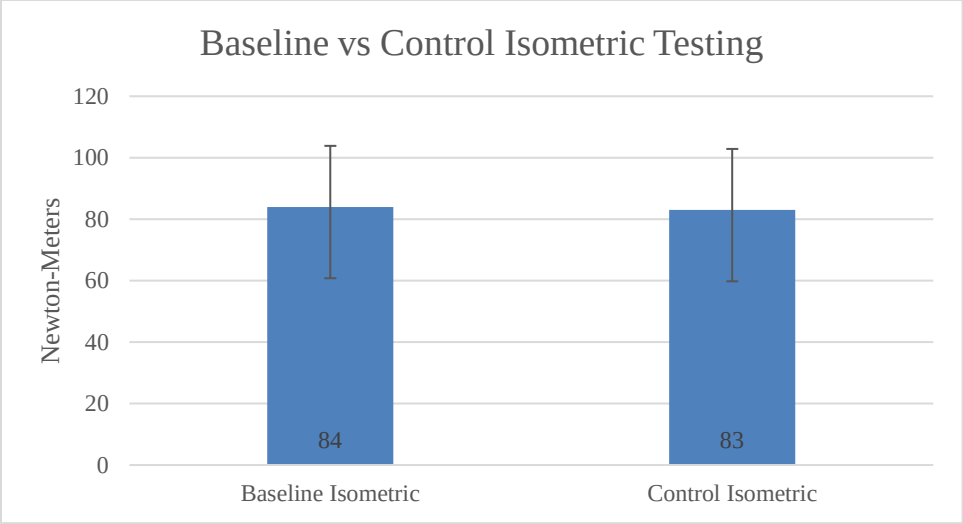

Figure 9: Paired T Test Baseline vs Control (Isometric $45^{o/s}$)

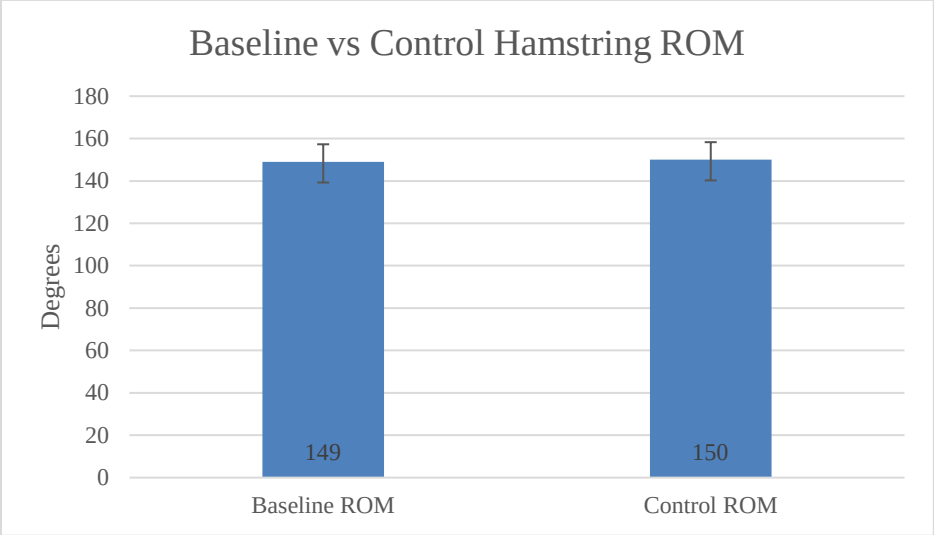

Figure 10: Paired T Test Baseline vs Control (Range of Motion)

4.2 Isokinetic Testing ($60^{o/s}$)

A two way repeated measures ANOVA was performed for independent variables of treatment and time as well as any treatment/time interaction. Mean differences were compared following an isokinetic strength test at $60^{o/s}$. The results are presented in Figure 11 below. No significant differences were found for treatment, time or

treatment/time variables. Mauchy tests for sphericity were significant for the treatment factor (p=.000) and treatment time interaction (p=.013) which resulted in violations of the ANOVA homogeneity of variance assumptions. Therefore, Greenhouse-Geisser corrections were used to determine the adjusted p values to determine any significance. There was no significant treatment main effects [F (1.248, 30) = 2.938, p=.087]. Greenhouse-Geisser correction for treatment and time interaction found no significance effects [F (2.960, 30) = 1.063, p=.368].

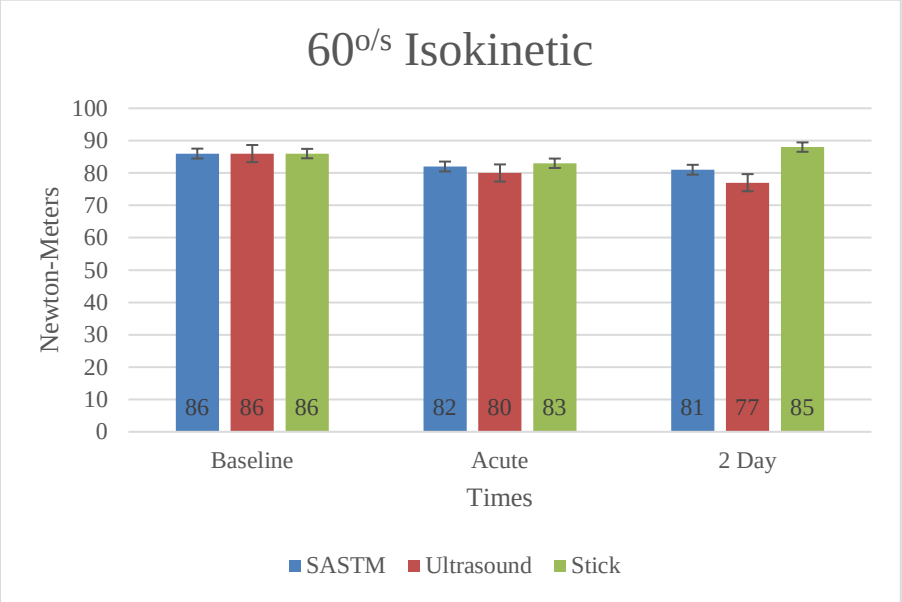

Figure 11: Two Way Repeated Measures ANOVA (Isokinetic $60^{o/s}$)

4.3 Isokinetic Testing ($180^{o}s$)

A two way repeated measures ANOVA was performed for independent variables of treatment and time as well as any treatment/time interaction. Mean differences were compared following an isokinetic strength test at $180^{o/s}$ The results are presented in Figure 12 below. Significance was found with treatment effect (p=.008). No significance with time or treatment and time interaction. Mauchy test for sphericity was significant

for treatment effect as well (p=.000) which resulted in violation of the ANOVA homogeneity of variance assumption. Greehouse-Geisser correction was used to determine new significant value (p=.184) for treatment effect. No significant treatment effects with correction [F (1.315, 30) = 1.817, p=.184]. No significant differences were found for the time [F (2.000, 30) = .504, p=.607] or treatment and time interactions [F (4.000, 30) = .600, p=.663]. No correction was needed for time or treatment and time interaction with no violation of sphericity.

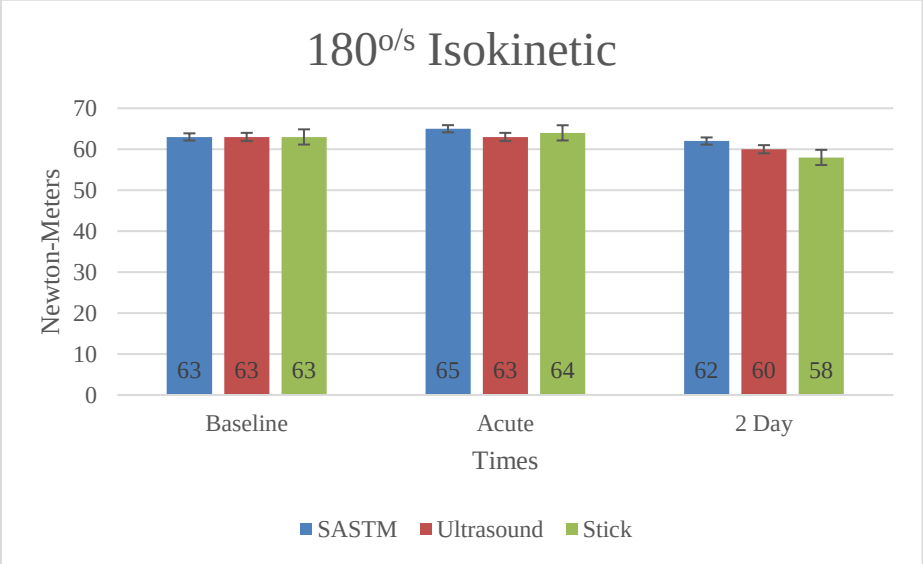

Figure 12: Two Way Repeated Measures ANOVA (Isokinetic 180$^{o/s}$)

4.4 Isokinetic Testing (240$^{o/s}$)

A two way repeated measures ANOVA was performed for independent variables of treatment and time as well as any treatment/time interaction. Mean differences were compared following an isokinetic strength test at 240$^{o/s}$. The results are presented in Figure 13 below. No significance was found with treatment, time or treatment and time interaction. Mauchy test for sphericity was significant for the treatment factor (p=.000)

which resulted in violation of the ANOVA homogeneity of variance assumption. Greenhouse-Geisser correction was used to determine new significant p value. There was no significance with correction and treatment effects [F (2, 30) = .493, p=.535]. No significant differences were found for the time [F (2.000, 30) = .323, p=.725] or treatment and time interactions [F (4.000, 30) = .192, p=.942]. No correction was needed for time or treatment and time interaction with no violation of sphericity.

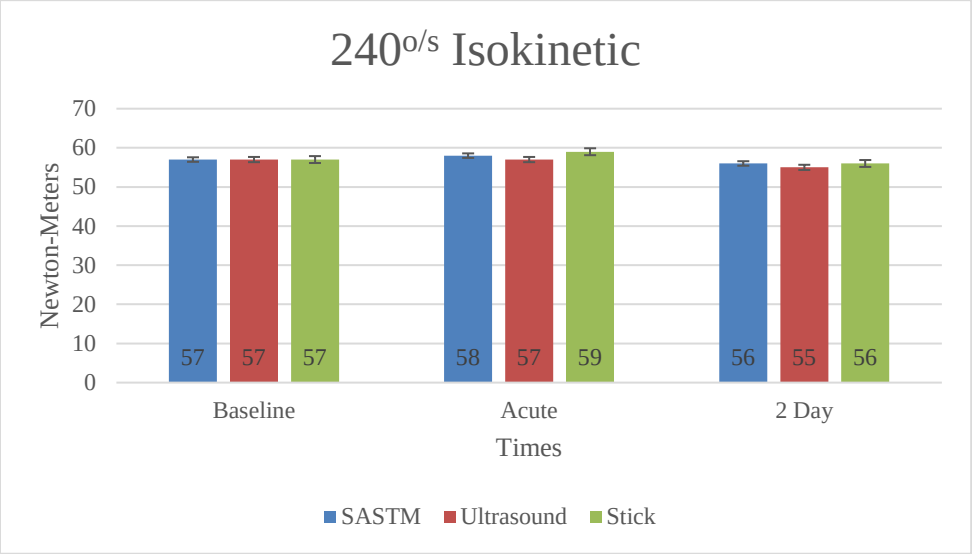

Figure 13: Two Way Repeated Measures ANOVA (Isokinetic 240$^{o/s}$)

4.5 Isometric (45º)

A two way repeated measures ANOVA was performed for independent variables of treatment and time as well as any treatment/time interaction. Mean differences were compared following an isokinetic strength test at 45º. The results are presented in Figure 14 below. No significance was found with treatment, time or treatment/time effects. Mauchy tests for sphericity were significant for the treatment factor (p=.000) and for treatment time interaction (p=.000) which resulted in violation of

the ANOVA homogeneity of variance assumption. Greehouse-Geisser correction was used to determine new significant p value. There was no significance with correction and treatment effects [F (1.374, 30) = .707, p=.448]. No significance with correction for treatment time interaction [F (4.000, 30) = .094, p=.948]. Time effect recorded [F (2.000, 30) = .389, p=.680].

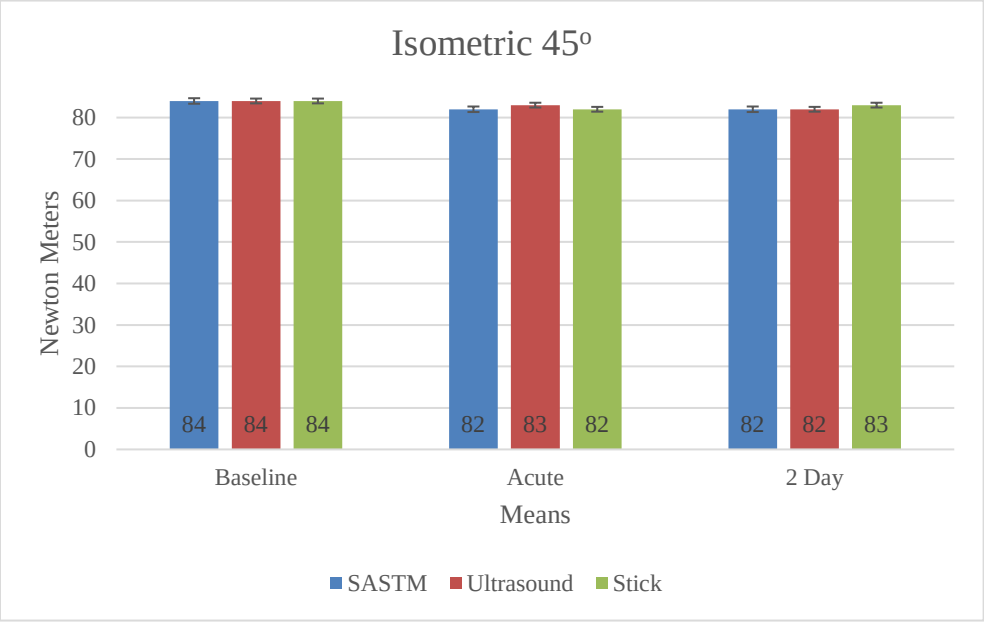

Figure 14: Two Way Repeated Measures (Isokinetic Isometric $45^{o/s}$)

4.6 ROM

A two way repeated measures ANOVA was performed for independent variables of treatment and time as well as any treatment/time interaction. Mean differences were compared following testing knee ROM. The results are presented in Figure 15 below. No significance was noted for treatment [F (2.000, 30) = 2.366, p=.103], time [F (2.000, 30) = 1.204, p=.307] or treatment/time [F (4.000, 30) = 2.057, p=.091]. Mauchy tests for sphericity was significant for the treatment factor (p=.000) which resulted in violation of

the ANOVA homogeneity of variance assumption. Greehouse-Geisser correction was used to determine a new significant p value [F (1.405, 30) = 2.366, p=.122].

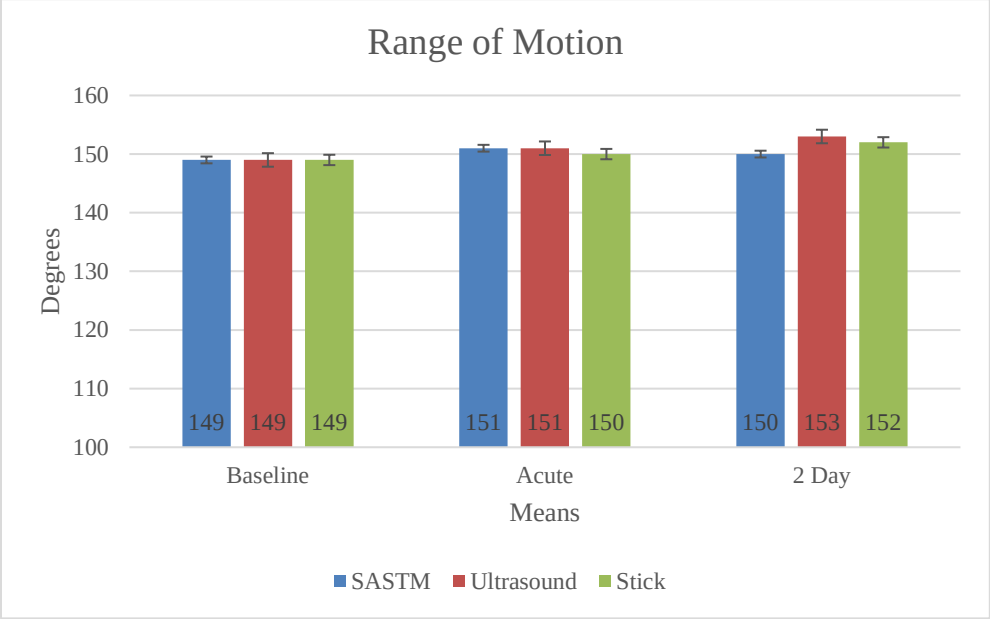

Figure 15: Two Way Repeated Measures (Range of Motion)

CHAPTER FIVE: DISCUSSION

The purpose of this research was to determine if Sound Assisted Soft Tissue Mobilization, SASTM™, could be used to create an acute effect on hamstring flexibility and/or isometric and isokinetic strength. STM is a hands on technique using physical massaging motions to aid in soft tissue and physiological change. SASTM™ is a specific technique tested to identify any significance with this treatment as opposed to therapeutic ultrasound and "The Stick". These methods of treatment were chosen due to the clinical involvement of SASTM™, ultrasound and "The Stick" to aid in decreasing pain, increasing ROM and possibly strength both isometrically and/or isokinetically. All three treatment methods are commonly used to create a massaging effect to create an increase in tissue temperature for physiological change. Each modality was chosen due to clinical convenience and previous training for these treatment methods.

Although not much specific research on the technique of SASTM™ it is highly similar to the other two STM techniques, ASTYM® and GRASTON®, in the review of literature. The process used was attempting to find acute effects with any or all of the chosen treatment methods. The ANOVA testing allowed the clinical investigator to measure each treatment against each participant to obtain full value of how each treatment method may or may not effect each participant.

Measurements were focused to ROM with participants lying supine with hip flexed 90^{o} and extension of the knee. Isometric strength was measured with a cybex to read max force output in newton meters of force with knee flexion relating to hamstring strength at 45^{o} of knee flexion. Isokinetic strength was measured in newton meters for the hamstring as well with torque speeds of 60, 180 and $240^{o/s}$.

Means were calculated for all results for analysis. T-tests resulted in no significant difference between the control or baseline measurements. These results show no significant difference between the participant's baseline measures before treatments and control leg during the research. This finding eliminated using the control leg for measurement comparison with other treatments overall.

Baseline measurements were then used to compare the (3 x 3) two way repeated measures ANOVA for three treatments (Ultrasound, SASTM^{TM} and "The Stick") compared to time (baseline, acute, 2day). As the results section concluded there were not significant findings with any of the treatments, times or treatment and time interactions.

With these results the null hypothesis was supported and a decrease chance of creating type I error with a decrease in the degrees of freedom with correction. Although acute changes were not observed, positive results in ROM and strength could occur considering limitations of the study. Areas of concern with the research performed may have lacked the ability to control participant's activity levels outside of the research. A participant's ability to create strength gains over the research time frame could have affected the results with individual training and weight lifting. Violation of sphericity showed to be a concern while increasing the possibility of a type I error. This violation was corrected to an extent using a Greenhouse-Geisser correction. By doing so the degrees of freedom decreases which decreases the chance of a type I error. Creating a type I error supports the random sample generated in this study lead to a false conclusion to the anticipated hypothesis. Sphericity focuses on the variance of difference between participants and groups to show the assumption of being equal. Violation of sphericity shows a variance of difference within paired differences. These results are due to

calculating the differences between groups, finding variance within each group and then comparing those differences. When the variance of the differences are unequal, sphericity is violated. Results clearly showing the variance of differences between groups were not equal

Research has shown results supporting both the null and the alternative hypothesis with a focus on acute ROM rather than strength in this research. Burke et al. found with a small clinical study of 22 participants that wrist strength and ROM could be increased through treatment.[70] Increased wrist ROM and strength were noted after the use of STM. Methods of treatment were IASTM and STM with the clinician's hands.[10] These increases were noted over a 10 treatment time frame to increase ROM and strength of the wrist.[70] Kivlan explained an increase in isometric strength of the lower extremity after ASTYM® treatment of the lower extremity and testing on a computerized leg press.[71] The body parts treated were anterior and lateral lower leg as well as the quadriceps and hamstring musculature. The hamstring muscle group and acute nature of the testing were the same muscular group and time frame used in our current study. 15-18% increase in power output was found to support a significant strength increase after STM treatment.[71] MacDonald found no significance in jump height, peak power output, or peak velocity after pre and post treatments after treatments of IASTM.[61] He states the standard time of IASTM treatments do not show an immediate increase in muscular performance for healthy patients.[71]

Markovic compared a foam roller and facial abrasion technique and found significant hip and knee ROM immediately after and 24 hours later. This technique can be supportive of the hypothesis with acute effects with STM. Acutely the research

derived significance with both groups observed at 10-19% vs 5-9% increase in ROM. The abrasion technique similar to SASTM™ was found to have a higher significance acutely. It was also the only technique found to be significant at 7-13% increase for 24 hours post treatment.

Mikesky identified using "The Stick" was not statistically significant for increasing ROM of the hamstrings/hip or isokinetic strength of the hamstring muscle group.[58] Although he did find a small positive change no greater than 3º for hamstring ROM/flexibility and 8.8N for isokinetic strength.[58] Barlow identified no significance with a submax isometric biceps femoris contraction after an acute single massage technique.[21] This 15 minute massage was compared to prone rest for 15 minutes and measured using an electromyography machine.[21] Findings show an actual decrease in the EMG output during post testing for each participant in the massage category.[21]

Ultrasound as a treatment did not have a significant finding although some research will support positive change. Akabari et al. suggested participants use either therapeutic ultrasound or passive massage to create ROM change.[73] Each participant was post tested at 0 and 3 weeks after treatment. Findings were an increase of approximately three degrees with just ultrasound intervention. Increase of five degrees with ultrasound and 15s of passive hamstring stretching. Eight degrees increase with ultrasound and 30s of passive hamstring stretching. Three degrees increase with only 15s of stretching and five degrees increase with 30s of stretching.[73] The research does support that acute changes can occur post ultrasound treatment although not significant increases. Lounsberry supports an approximate four degrees increase with ROM as well when comparing ultrasound and superficial heat pack intervention treatments. No significance

was found between treatments but increased ROM was noted.[74] In a review study of seven randomized controlled studies only two showed significance in positively altering the ROM post treatment and the results were short term lasting no more than 24 hours.[60,66] Although I did not find current research to support significant and acute ROM improvement it does show an overall trend that IASTM improves ROM in some capacity.

The findings as well as the recent and past literature show both positive and no change when IASTM is the intervention. These findings of increases although not significant in the research may support the hypothesis that IASTM can be used to aid in acute and/or long-term ROM increases even if not significant. STM has shown in the literature review and discussion that most forms of IASTM have a positive effect on ROM rather than strength. Clinically these results can be viewed as positive for patient outcomes but overall non-significant for acute changes. Overall, most research would support the null hypothesis being non-significant and change will occur with IASTM when related to ROM and / strength increase. Findings for strength increases were also not significant although some research did mention of small increases both acutely and long term. The literature review and discussion speak to strength increases occurring due to efficient muscle firing post treatment with STM. Strength increases were not found in the literature with the treatment of ultrasound during the research.

"The Stick" seems to be supported as a STM device that can increase both ROM and strength but not to a significant level according to the literature review. As mentioned it was shown "The Stick" did create ROM increases and some power outputs when used and then measured post treatment acutely. Specific research was not found to support ROM and/or strength gains over time by using "The Stick".

5.1 Research Study Questions and Hypotheses Discussion

Can there be an acute effect on ROM after performing Sound Assisted soft Tissue Mobilization on a healthy male participant with a noted lack of ROM? This research showed no significant change in ROM, isometric and/or isokinetic strength. Significance was only found in one instance with $180^{o/s}$ isokinetic strength. In this case there was a violation of sphericity and with the Greenhouse-Geisser correction this finding was no longer significant between treatments. Therefore the alternative hypotheses that SASTM™ increases ROM and strength in the lower extremity were not supported.

5.2 Analysis and Results Reflection Discussion

The results of the research did not support the proposed hypotheses. The research showed no significant changes to show any of the treatment methods created significant change in ROM, isometric or isokinetic strength. None of the results showed a significant difference with the Sound Assisted Soft Tissue Mobilization technique when compared to time, treatment or time and treatment interactions.

1. SASTM™ was non-significant for acute changes in ROM
2. SASTM™ was non-significant for acute changes in isometric strength gains
3. SASTM™ was non-significant for acute changes in isokinetic strength for 60, 180 or $240^{o/s}$.
4. SASTM™ was non-significant when compared to ultrasound and The Stick for positive results

These findings do not support any of the hypotheses originated at the beginning of the study. A power analysis was completed to set a number of significant participants for this research. Considering the continued violation of sphericity at multiple

interventions/treatments it leads me to believe it may have had a more diverse group of participants. It may seem the random sample of participants was not as significantly different due to strength and ROM for male athletes. Violation at several levels may have led to more liberal research results making a larger chance for a type I error. This possible type I error may have led the research to a false conclusion considering the random sampling of participants. The Greenhouse-Geisser correction to aid in the p value was used to lower the chance of a type I error by lowering the df value and increasing the F value. Greenhouse-Geisser corrections resulted in no significance when altering p value as well as df and F values.

5.3 Conclusion

The research did not statistically support any of the original hypotheses. The research and literature does support mild changes in ROM but not at a range considered significant to support for research. Results show that no treatment, time or treatment/time interaction resulted in significance which may be attributed to only using acute affects after one treatment. Ultrasound and "The Stick" in the literature review did identify some positive change in ROM but little with strength. Neither of these positive results were significant according to the research. Ultrasound has not been supported by the research as having the capabilities of acute changes with flexibility or strength at a significant level although small positive increase can be found according to the literature review. This method is best served to be used over time in conjunction with other modalities and treatments to increase flexibility and strength. "The Stick" has been said to create acute changes in flexibility by the manufacturer. Research by Mikesky et al. show no significant results in acute flexibility change by using The Stick.[58] They noted

this may be due to breaking down “barrier trigger points”. [58] It is also noted that considering The Stick is a form of massage that has been used to cause multiple physiological effects to support an increase in flexibility. The idea that treatment with ultrasound and “The Stick” over time would create a more optimal environment for healing in the body for significant change makes more sense. [58]

Although anecdotal evidence supports the use of STM to create minor change there is little research to support acute significant change and the use of STM for this reason. As the research suggest and the literature supports in some areas that ROM can be altered with IASTM as well as several other forms of modalities but time may be the deciding factor. Treatment over time with “The Stick” and IASTM seem to be the method of choice to see less fibroblastic material in soft tissue, more force production, decrease pain and flexibility.[52, 53] Research has shown that with noted IASTM methods anywhere from 5-12 treatments can produce less pain, more ROM and other physiological responses.[52, 53] Although not statistically significant each participant resulted in different positive changes that did result in minor ROM increases. Overall the research does not support SASTM™ for acute change in ROM or strength gains either isometrically or isokinetically. The literature and research states and shows that further studies are necessary to show significant findings for IASTM and whether it can increase ROM or strength. Focus may need to shift to neurological involvement and mechanoreceptor alteration in the soft tissue to allow elongation and healing to be supportive. The idea of treatments over time and combining modalities should be a focus of future research. Recent research as shown in the literature review is moving toward mechanoreceptor involvement and neurological focus with future research. Although no

significance resulted from the current research dissertation it may be worthy to look at this anecdotally to support the use of SASTM^{TM}, ultrasound and “The Stick” in therapeutic rehabilitation to create an increase in acute ROM and strength.

APPENDIX A

INDIANA UNIVERSITY INFORMED CONSENT STATEMENT FOR

Acute Effects of Soft Tissue mobilization modalities on Lower Extremity Flexibility, Isokinetic, and Isometric Strength

You are invited to participate in a research study to look at the acute effects of soft tissue mobilization on lower extremity strength and flexibility. You were selected as a possible participant because you have been identified as a Manchester University athlete**.** We ask that you read this form and ask any questions you may have before agreeing to be in the study.

The study is being conducted by Jeffrey A. Beer ATC of Manchester University in the department of Exercise and Sport Sciences and Dr. Rafael Bahamonde of Indiana University Purdue University of Indianapolis of the HYPER department.

STUDY PURPOSE

The purpose of this study is to determine if there are immediate effects on lower extremity strength and flexibility after having soft tissue mobilization procedures. The study does not include any drugs or devices that are considered experimental or investigational (meaning it is not approved by the Food and Drug Administration (FDA).

NUMBER OF PEOPLE TAKING PART IN THE STUDY:

If you agree to participate, you will be one of 30 individuals participating in this research. The study will involve all 30 participants being treated with the three different methods. Participants to be included into this research are out of season division III male athletes with no quadriceps or hamstring injury present. Athletes must have a flexibility ROM less than $90^{o/s}$ of hip flexion with knee extension while lying face up. Participants who will be participating in this research are free to dismiss themselves from the study at any point. The number of participants was determined by the use of a statistical power analysis.

PROCEDURES FOR THE STUDY:

If you agree to be in the study, you will do the following things:

Each participant will have three different techniques performed on him or her as an out of season athlete. The three techniques include a massage technique called SASTM^{TM} which uses specific plastic tools to manually massage muscles. The next device is "The Stick" which is designed with rollers and used to manually massage the muscle. The last is Therapeutic Ultrasound, which is a modality that generates energy through electrical power through a rounded device used to manually massage and transmit energy into muscles. A double blind experimental design will be used. Each participant will be blinded to the fact that one of these modalities is being researched to determine its effects on ROM and specific strength. Participants will not be told which method of treatment will be used for outcomes when it is performed. The individual doing the testing will also not know which treatment method was done when testing post

treatment. Participants will be asked to not divulge which treatment was performed on them prior to testing.

Before any testing is done, the participant will be taken through a familiarization period for each treatment and testing. Each participant before testing will perform 10 minutes of stationary biking with a minimum speed of 5 MPH as a preparation to testing. Initial baseline measurements of muscle strength and flexibility will be conducted for each participant. Each participant will perform maximal knee extension and flexion muscle actions on an isokinetic Cybex 300 machine as well as a fixed 45-o angle of knee flexion to test strength isometrically both in flexion and extension of the knee to determine quadriceps and hamstring strength. A Cybex 300 machine is a device that measures specific strength in muscles after performing specific motions. Specific angles and speeds can be manipulated with the Cybex 300 machine as well. The isokinetic and isometric testing will be performed at one speed, $60^{o/s}$ per second. After isokinetic and isometric strength testing, the flexibility of the hamstrings and quadriceps will be assessed using a goniometry application on the iPad for knee flexion and extension, respectively. Clinicians to determine the ROM a joint moves through in comparison to other joints objectively use a goniometer device. During the knee flexion test, the participant will be instructed to extend the knee to full extension and then flex the knee as far as possible bringing the heel toward the gluteus maximus. The ROM for knee flexion will be measured using a goniometer on an iPad application with videography. To measure knee extension the participant will be lying face up with $90^{o/s}$ of hip flexion determined by the goniometer application and then asked to extend only the lower leg (below the knee) to determine hamstring flexibility.

Once baseline testing is finished, each participant will be tested receiving one of the three modalities. Post treatments each leg will be tested again for flexibility, strength and be recorded. Two days later the same participants will report to have measurements again for a comparison to sub-acute effects. One week later each participant will have pretesting with one randomly chosen leg to have "The Stick" performed and the other to have SASTM^{TM} performed. Again once completed each participant will go through all measurements focused on isokinetic, isometric strengthening and flexibility immediately following testing. Two days later each participant will be required again to have measurements of isometric, isokinetic and ROM for comparison.

Participants will be asked to be a part of four different bouts of measurements where during three of them treatments will be performed. Each bout of treatment and measurement should take no longer than 45 minutes.

Data analysis will include computation of descriptive statistics of participant demographics and all other variables. Statistical analysis to determine the effects of the control, placebo, and experimental interventions on strength and flexibility will involve using two-way repeated measures analysis of variance.

RISKS OF TAKING PART IN THE STUDY

There are minimal risk associated with the study. Risks such as mild bruising of the skin, skin tenderness or redness as the result of the pressure applied to the skin during the SASTM treatment. The student investigator is a Certified Athletic trainer, has been trained, and uses the technique on regular basis.

If necessary, the following measures will be taken to minimize the risks:

1. Use of ice after treatment for superficial soreness/tenderness
2. Two day break after treatment before another treatment is performed (minimum)
3. Monitoring and re-checking skin after day of treatment

BENEFITS OF TAKING PART IN THE STUDY:

The benefits are gaining knowledge of what modalities/treatments may aid an athlete in obtaining an increase in in ROM and/or strength.

ALTERNATIVES TO TAKING PART IN THE STUDY:

There are no alternatives if you do not want to participate in the study. As well as there are no ramifications if someone does not want to participate.

CONFIDENTIALITY

Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP). All documents will be maintained on a secure computer that is password protected.

All information will be destroyed after publication possibilities have been exhausted. Any publication of information will be protected by excluding any identifiable information towards the participating participant.

COSTS: There is no cost to participate in this research

PAYMENT: There will be no compensation for anyone participating in this research.

COMPENSATION FOR INJURY

In the event of physical injury resulting from your participation in this research, necessary medical treatment will be provided to you and billed as part of your medical expenses. Costs not covered by your health care insurer will be your responsibility. In addition, it is your responsibility to determine the extent of your health care coverage. There is no program in place for other monetary compensation for such injuries. However, you are not giving up any legal rights or benefits to which you are otherwise entitled. If you are participating in research, which is not conducted at a medical facility, you will be responsible for seeking medical care and for the expenses associated with any care received.

CONTACTS FOR QUESTIONS OR PROBLEMS

For questions about the study or a research-related injury, contact the researcher Jeffrey A. Beer MA, LAT, ATC. If you cannot reach the researcher during regular business hours, (8:00AM-5:00PM), please call the Exercise Science and Athletic Training Department.

In the event of an emergency, you may contact Jeffrey A. Beer MA, LAT.

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Participants Office at (317) 278-3458 or [for Indianapolis] or (812) 856-4242 [for Bloomington] or (800) 696-2949.

VOLUNTARY NATURE OF STUDY

Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with Manchester University or athletic team involvement.

The investigator without regard to your consent in the following circumstances may terminate your participation: If a participant reports an injury to the hamstring or quadriceps musculature during the research study that participant will be removed for safety and effective reasons.

PARTICIPANT'S CONSENT
In consideration of all of the above, I give my consent to participate in this research study.
I will be given a copy of this informed consent document to keep for my records. I agree to take part in this study.

Participant's Printed Name: _____

Participant's Signature:_____

Date:_____

Printed Name of Person Obtaining Consent: _____

Signature of Person Obtaining Consent:_____
Date:
_____

APPENDIX B

Research Study Opportunity for
Out of Season Athletes
Out of Season Athletes needed for
Dissertation Study

Purpose:	To analyze the immediate effects of specific treatments on strength and flexibility
Participants:	Thirty male out of season athletes 18-23 years of age with no leg injuries currently or in past 6 months.
Methods:	Strength will be measured with a Cybex 300 isokinetic machine and ROM with IPad video application.
Time:	Approximately one 45-60 min session.
Benefits:	A better understanding of how different modalities effect ROM and strength in the leg acutely.
When:	By appointment.
Where:	Human Performance Laboratory PERC 208, Manchester University Physical Education Recreation Center
Contact:	Jeffrey Beer

APPENDIX C

Email to Students for Recruitment

Students,

My name is Jeffrey A. Beer and I emailing today to determine if you would be interested in being a participant in my dissertation research. The research focuses on therapeutic techniques to aid in acute change in flexibility and strength. The purpose of this study is to determine if there are immediate effects on lower extremity strength and flexibility after having three types of soft tissue mobilization procedures. The study does not include any drugs or devices that are considered experimental or investigational (meaning the Food and Drug Administration (FDA) do not approve it.

RISKS OF TAKING PART IN THE STUDY:

There are minimal risk associated with the study. Risks such as mild bruising of the skin, skin tenderness or redness as the result of the pressure applied to the skin during the SASTM treatment. The student investigator is a Certified Athletic trainer, has been trained, and uses the technique on regular basis.

If necessary, the following measures will be taken to minimize the risks:

1. Use of ice after treatment for superficial soreness/tenderness
2. Two day break after treatment before another treatment is performed (minimum)
3. Monitoring and re-checking skin after day of treatment

BENEFITS OF TAKING PART IN THE STUDY:

The benefits are gaining knowledge of what modalities/treatments may aid an athlete in obtaining an increase in in ROM and/or strength.

ALTERNATIVES TO TAKING PART IN THE STUDY:

There are no alternatives if you do not want to participate in the study. As well as there are no ramifications if someone does not want to participate.

CONFIDENTIALITY

Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP). All documents will be maintained on a secure computer that is password protected.

All information will be destroyed after publication possibilities have been exhausted. Any publication of information will be protected by excluding any identifiable information towards the participating participant.

COSTS: There is no cost to participate in this research

PAYMENT: There will be no compensation for anyone participating in this research.

COMPENSATION FOR INJURY

In the event of physical injury resulting from your participation in this research, necessary medical treatment will be provided to you and billed as part of your medical expenses. Costs not covered by your health care insurer will be your responsibility. In addition, it is your responsibility to determine the extent of your health care coverage.

There is no program in place for other monetary compensation for such injuries. However, you are not giving up any legal rights or benefits to which you are otherwise entitled. If you are participating in research, which is not conducted at a medical facility, you will be responsible for seeking medical care and for the expenses associated with any care received.

CONTACTS FOR QUESTIONS OR PROBLEMS

For questions about the study or a research-related injury, contact the researcher Jeffrey A. Beer MA, LAT, ATC. If you cannot reach the researcher during regular business hours, (8:00AM-5:00PM), please call the Exercise and Sport Sciences Department.

In the event of an emergency, you may contact Jeffrey A. Beer MA, LAT, and ATC. For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Participants Office at (317) 278-3458 or [for Indianapolis] or (812) 856-4242 [for Bloomington] or (800) 696-2949.

VOLUNTARY NATURE OF STUDY

Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with Manchester University or athletic team involvement.

The investigator without regard to your consent in the following circumstances may terminate your participation: If a participant reports an injury to the hamstring or quadriceps musculature during the research study that participant will be removed for safety and effective reasons.

I appreciate your time and consideration

Jeffrey A. Beer

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CURRICULUM VITAE

Jeffrey Allen Beer

Education

Ball State University (Undergraduate): May 2000
Major(s): Athletic Training
O: BS, Applied Science & Technology

Kent State University (Graduate): May 2002
Major(s): Sport & Recreation Management
O: MA, Sport and Recreation Management

Indiana University (Doctorate): July 2019
Major(s): Health and Rehabilitation Sciences
O: PhD, Health and Rehabilitation Sciences

Professional/Teaching Load

2015-Present	Department Chair Exercise Science and Athletic Training Department, Educational Chair for IATA, Tenured Associate Professor and Undergraduate Program Director with teaching responsibilities in Therapeutic Rehabilitation, Administration in Athletic Training, Functional Kinesiology, Therapeutic Modalities, Medical Diagnostic Imaging, Musculoskeletal Assessment: Upper Extremity, Clinical Experience, Field Experience and First Aid, International Sports Medicine Travel Abroad trip to Ireland and England
2012-2015	Tenured Associate Professor in Exercise and Sport Sciences Department and Undergraduate Program Director with teaching responsibilities in Therapeutic Rehabilitation, Administration in Athletic Training, Functional Kinesiology, Therapeutic Modalities, Medical Diagnostic Imaging, Musculoskeletal Assessment: Upper Extremity, Clinical Experience, Field Experience and First Aid
2009-2012	Assistant Professor in Exercise and Sport Sciences Department and Undergraduate Program Director with teaching responsibilities in Therapeutic Rehabilitation, Administration in Athletic Training, Functional Kinesiology, Therapeutic Modalities, Medical Diagnostic Imaging, Musculoskeletal Assessment: Upper Extremity, Clinical Experience, Field Experience and First Aid
2007-2009	Assistant Professor in Exercise and Sport Sciences Department and Head Athletic Trainer with teaching responsibilities in Therapeutic

	Rehabilitation, Administration in Athletic Training, Functional Kinesiology, Therapeutic Modalities, Medical Diagnostic Imaging, Musculoskeletal Assessment: Upper Extremity, Clinical Experience, Field Experience and First Aid
2006-2007	Adjunct Instructor in Exercise and Sport Sciences Department with teaching responsibilities in Clinical Experience, Field Experience and Biomechanics.

Committee Work

2016-Present	Substance Abuse Prevention and Education Committee, Graduate Athletic Training Admission Committee, Graduate and Professional Curriculum and Assessment Committee, Athletics Committee, Academic Governance Committee
2014-2015	Substance Abuse Prevention and Education Committee, Graduate Athletic Training Admission Committee, Technology Committee
2013-2014	Substance Abuse Prevention and Education Committee, Graduate Athletic Training Admission Committee
2012-2013	Substance Abuse Prevention and Education Committee, Discussion Day Committee, Graduate Athletic Training Admission Committee
2011-2012	Substance Abuse Prevention and Education Committee, Co-Advisor MCATC, Retention Committee, Choices Grant Committee
2010-2011	Substance Abuse Prevention and Education Committee, Co-Advisor MCATC, Retention Committee, Choices Grant Committee
2009-2010	Substance Abuse Prevention and Education Committee, Co-Advisor MCATC, Discussion Day Committee, Choices Grant Committee
2008-2009	Academics Policy Committee & Substance Abuse Prevention and Education Committee, Subcommittee member reporting on college labs, Identity Theft Protection Taskforce, Co-Advisor MCATC
2006-2008	Substance Abuse Prevention and Education Committee, Co-Advisor MCATC

Teaching

2011-Present
- Average of 25-30 Advisees
- Therapeutic Rehabilitation trip to the YMCA pool for Aquatic Therapy training
- Performed and organized speed interviewing for administration students
- Faculty representative for several students in internships and practicums
- Instrumental in helping students obtain graduate assistantships and job placement

2010-2011
- 46 Advisees
- Therapeutic Rehabilitation trip to the YMCA pool for Aquatic Therapy training
- Performed site visits to our outside clinical sites
- Instrumental in helping students obtain graduate assistantships and job placement

2009-2010
- Athletic Training student trip to cadaver lab at IPFW in Fort Wayne, Indiana
- 24 Advisees
- Therapeutic Rehabilitation trip to the YMCA pool for Aquatic Therapy training
- New class prep for Musculoskeletal Assessment: Upper Extremity and Medical Diagnostic Imaging
- Performed site visits to our outside clinical sites

2008-2009
- Athletic Training student trip to cadaver lab in Muncie, Indiana
- 26 Advisees
- Instrumental in helping our students find graduate positions within Ortho NorthEast (formally Orthopaedics NorthEast)

2007-2008
- Athletic Training student trip to cadaver lab in Muncie, Indiana
- Biomechanics class trip to Midwest Health Strategies Motion Analysis Therapy Complex
- New class preps for Therapeutic Rehabilitation, Sport Psychology, and Therapeutic Modalities
- Instrumental in helping our students find graduate positions at IPFW and Indiana Tech

Scholarship

2011-2019
- Dissertation work on PhD at IUPUI (July 2019)
- Continued attendance at state, district and national convention
- Continued submission of abstracts to the Fort Wayne Teaching Conference

- 3 accepted for presentation

2010-2011
- Continued work on PhD at IUPUI
- Guest lecture on administrative responsibilities/insurance for ESS 410
- Guest in ESS 410 to enhance interviewing skills with students

2009-2010
- Application process to enroll into PhD program at IUPUI
- Professional Development: Classroom Evaluations/Observation (11/5/09)
- Professional Development: Difficult Classroom Situations (11/4/09)
- Professional Development: Gateway Training (10/1/09)
- Guest in ESS 410 to enhance interviewing skills with students.
- Guest Lecture on administrative responsibilities/insurance for ESS 410
- Attended Indiana Athletic Trainers Association annual meeting in Indianapolis (November 2009)
- Compiling and writing Self Study for athletic training accreditation, CAATE.

2008-2009
- Guest Lecture on administrative responsibilities/insurance for ESS 410
- Attended Indiana Athletic Trainers Association annual meeting in Indianapolis (October 2008)
- Obtained training on biomechanical software, Dartfish, to utilize in my classroom teachings
- Attended Great Lakes Athletic Trainers Association annual meeting in Fort Wayne, IN (March 2009)

2007-2008
- Attended Indiana Athletic Trainers Association annual meeting in Indianapolis (October 2007)
- Attended National Athletic Trainers Association annual meeting in St. Louis, MO (June 2008)
- Guest lecture on Pharmacology for ESS 410

2006-2007
- Guest lecture on Pharmacology for ESS 410

Service

2010-2011
- Member of "Choices" grant committee
- Commission on Accreditation of Athletic Training Education Site Visit

2009-2010
- Member of the Kansas Lunch team helping those that are homesick and wanting to leave school
- Sports Medicine organization for college health fair

- Director of Extreme Home Makeover community service project with students
- Organization of Angel tree for Christmas presents to those less fortunate
- Member of the "Choice" grant committee applying for funds through NCAA for alcohol education
- Organization of 2nd annual basketball tournament "Power Hour" to promote non-drinking on campus

2008-2009

- GLATA convention committee member responsible for educational guest speakers and exhibit hall
- Member of the "Choice" grant committee applying for funds through NCAA for alcohol education
- Organization of a basketball tournament "Power Hour" to promote non-drinking on campus

2007-2008

- Member of the "Choice" grant committee applying for funds through NCAA for alcohol education
- Instrumental in saving Manchester College $26,000 in premium costs through insurance research

Athletic Training Experience

2007-Present **Manchester University**

- Department Chair Exercise Science and Athletic Training Department
- Program Director Athletic Training Education Program (7 years)
- Head Athletic Trainer (2 years)
- Responsibilities: working with athletic training staff, daily interaction with physicians and health care providers, interaction with athletic training students
- Assisting in all aspects of injury prevention and rehabilitation, including acute and chronic care, competition travel, supervising athletic training students, overseeing budget, purchasing, insurance duties, alcohol and drug liaison, as well as maintenance of training room facilities and equipment.
- Sport coverage assignments with football, men's basketball, women's soccer and women's basketball

2004-2006 **Orthopedics Northeast**

- Certified and Licensed Athletic Trainer. Interim Head Athletic Trainer
- Responsibilities: working with all athletic training staff, daily interaction with physicians and health care providers, interaction athletic training students
- Assisting in all aspects of injury prevention and rehabilitation, including acute and chronic care, competition travel, supervising athletic training students, overseeing budget, purchasing, insurance duties, alcohol and drug liaison, as

well as maintenance of training room facilities and equipment.
- Sport coverage assignment football and men's basketball.
- Adjunct teaching responsibilities for fall and spring semesters.

2002-2004 **Midwest Health Strategies**
- Lead Athletic Training Clinician/Certified and Licensed Athletic Trainer.
- New program development, rehabilitation, outreaching to local high schools

Memberships
- National Athletic Trainers Association, spring 1997-Present - GLATA Association, Spring 1997-Present
- Indiana Athletic Licensure Board: 2002-Present

Certifications
- NATA Certified Athletic Trainer: May 2000-Present
- Indiana Licensed Athletic Trainer: 2002-Present
- Red Cross CPR/First Aid/AED Lay Instructor Certified 2000-Present
- Red Cross Professional Rescuer Instructor Certified, 2006-Present
- Red Cross Professional Rescuer Certified, 2000-Present
- Augmented Soft Tissue Mobilization (ASTYM®), April 2003-Present
- Certified Ergonomic Assessment Specialist (CEAS), June 2003-Present
- NATA Approved Clinical Instructor (ACI), 2002-Present
- CKTP, Kinesiotaping certification, 2015-Present