THE EFFECTS OF THERMOSTIM INSTRUMENT ASSISTED SOFT TISSUE MOBILIZATION AND SUPERFICIAL HEAT ON RANGE OF MOTION OF THE HAMSTRINGS AND PERCEIVED PATIENT COMFORT

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The Effects of ThermoStim Instrument Assisted Soft Tissue Mobilization and Superficial Heat on Range of Motion of the Hamstrings and Perceived Patient Comfort

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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

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ABSTRACT

Instrument assisted soft tissue mobilization (IASTM) and superficial heat have reportedly increased range of motion and perceived patient comfort. The ThermoStim provides IASTM and superficial heat simultaneously. Only one study (Guffey, et al., 2013) has been published using the ThermoStim. The purpose of this study was to determine if the range of motion of the hamstrings can be increased utilizing IASTM, and whether superficial heat would create an additional increase in range of motion and perceived patient comfort.

Thirty college-aged student-athletes (15 males, 15 females) participated. Pre- and post-treatment range of motion was measured by goniometry with the hip flexed to 90° with passive knee extension. A statistically significant difference existed between pre- and post-treatment range of motion for both treatment times. There was no significant difference between groups due to the inclusion of superficial heat for range of motion or perceived patient comfort.

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CHAPTER 1. INTRODUCTION

Instrument assisted soft tissue mobilization (IASTM) grew from what began as cross-friction massage techniques, and was popularized by James Cyriax, M.D., who theorized that cross-friction massage could help treat adhesions and scar tissue within muscles, tendons, and ligaments (Chamberlain, 1982). Healthcare practitioners' hands would tire after performing countless cross-friction massage treatments. This resulted in the clinician not being able to apply enough pressure to treat the deeper tissues. Therefore, instruments of wood, ceramic, and later stainless steel were developed to create the same or greater pressure to treat deep tissues without tiring the practitioner. Graston Technique® and ASTYM® are two types of IASTM available today, with the former using six stainless steel instruments and the latter using three plastic instruments. Research behind both Graston Technique® and ASTYM® show a host of positive outcomes: specifically increases in range of motion (Black (2010); Howitt, Jung, & Hammonds, (2009); Howitt, Wong, & Zabukovec, (2006); McCormack (2012); Slaven & Mathers (2011)) and decreases in perception of pain post-intervention (Howitt, S., Jung, S., & Hammonds, N. (2009); McCormack (2012); McCormack (2012); Miners & Bougie (2011); Papa (2012); Papa (2012); Slaven & Mathers (2011)).

In addition to IASTM, superficial heat has also shown promise in treating musculoskeletal injuries. Modality textbooks state that heat is indicated for sub-acute to chronic injuries to increase range of motion and control pain (Starkey, 2004). When superficial tissues reach a temperature of 104-113° F, therapeutic effects such as muscle relaxation, vasodilation, increased venous and lymphatic return, and nerve sedation occur. When tendons, ligaments, or muscle fibers reach these same temperatures, collagen becomes more extensible and viscosity increases in the tissues (Starkey, 2004).

Dynatronics, a healthcare modality company, announced a new product at the National Athletic Trainer's Association Symposium in 2012. It was a handheld probe that attached to the

Dynatronics Solaris Unit, which is commonly found in athletic training rooms. This probe, named the ThermoStim, is capable of simultaneously performing instrument assisted soft tissue mobilization, electrical stimulation, and either superficial heat or superficial cold; this is packaged in one compact, handheld device. Dynatronics claims that, by performing several modalities at once, a healthcare practitioner saves time on treatments and it improves patient tolerance and compliance. However, there has been limited research on the ThermoStim probe and treatments are often combined with other modalities. No research thus far has determined the effectiveness of IASTM performed with the ThermoStim probe to increase range of motion. There has also been no research combining superficial heat with IASTM through the ThermoStim probe to create additional range of motion or greater patient comfort during treatment.

Statement of Problem

The Dynatronics ThermoStim probe can be used to treat chronic muscle and tendon strains or ligament sprains when adhesions or scar tissue are causing the injury. However, since the ThermoStim is quite new, there has been very little research. Previous research has included several other modalities, therefore the outcomes could be related to those modalities and not the ThermoStim itself. It is unknown if utilizing IASTM and superficial heat with the ThermoStim probe can create greater range of motion of the hamstrings muscle group and increase patient comfort during treatment.

Purpose of Study

The purpose of this study was to determine if the range of motion of the hamstrings muscle group could be increased utilizing instrument assisted soft tissue mobilization (IASTM) through the Dynatronics ThermoStim probe. This study also determined whether performing IASTM with simultaneous superficial heat through the Dynatronics ThermoStim probe could create greater range of motion than IASTM alone. In addition, both groups completed a survey post-intervention to determine whether superficial heat had an effect on patient comfort.

Research Questions

1. Does instrument assisted soft tissue mobilization using Dynatronics ThermoStim increase range of motion for tight hamstrings, and if so, by how many degrees?
2. Does utilizing superficial heat on the ThermoStim probe with IASTM cause greater increases in range of motion than ThermoStim alone?
3. Does using superficial heat with IASTM through the ThermoStim probe increase participant comfort during treatment?

Definition of Terms

- Instrument Assisted Soft Tissue Mobilization (IASTM): The use of tools to increase blood flow and decrease restrictions in injured soft tissue. Tools can go deeper into the tissue than fingers or hands alone. Tools can be made of wood, ceramic, plastic, stone, or metal. IASTM breaks up tissue abnormalities, such as scars, and assists in first stage healing by creating microtrauma. (American Chiropractic Association)
- Massage: The systematic manipulation of the body's tissues to promote local and systemic relaxation or invigoration, increase local blood flow, break down adhesions, and encourage venous return (Starkey, 2004).
- Cross Friction Massage: The basis of instrument assisted soft tissue mobilization. Applied to tissues in a transverse motion to separate adhesions or scar tissue in muscles, tendons, or ligaments, treat trigger points and tendinitis, and to facilitate local blood perfusion (Starkey, 2004).
- Superficial Heat: Application of therapeutic thermal agents to specific body areas experiencing injury or dysfunction; must be capable of increasing the skin temperature to

104°-113°F (Starkey, 2004). Superficial heating reaches to depths of less than 2cm below the skin and include infrared lamps, moist hot packs, paraffin baths, and warm whirlpools (Starkey, 2004). The ThermoStim probe uses conduction to transmit heat between the probe head and the body (Dynatronics, 2012).

- Graston Technique®: A form of evidence based manual therapy known as instrument assisted soft tissue mobilization, using six different stainless steel instruments to apply treatment to scar tissue restrictions or adhesions in ligaments, tendons, or muscles (Carey-Loghmani, Schrader, & Hammer, 2015).
- Range of Motion: The distance, measured in degrees, that a limb moves in one plane (Starkey, 2004).

Importance of Study

The Dynatronics ThermoStim probe has only been used in one published research study (Guffey, et al., 2013). However, a variety of other therapeutic modalities were used simultaneously, therefore limiting the amount of clinical applicability. The published research was a pilot study with fourteen participants, which limits the generalizability of the study. The current study included 30 participants and will help provide information about range of motion increases and patient comfort due to IASTM and superficial heat using the Dynatronics ThermoStim.

Limitations of Study

- Participants whose pre-intervention range of motion was closer to the limits (40°-70°) could have resulted in more or less range of motion.
    - Participants with limited pre-intervention range of motion may have had exaggerated increases, while results may have been less significant for those with greater range of motion prior to the intervention.

- Using a predetermined treatment for each participant could have led to false results when compared to individualized treatments.
- Participants in this study were injury-free and healthy, but were classified as having tight hamstrings.
- Small sample size

Delimitations of Study

1. All participants were free from any skin disorders and open wounds.
2. All participants were females or males with hamstring tightness, meaning less than 70° passive knee extension when the hip was flexed to 90°.
3. All participants were current student-athletes at a Division III college in the mid-west.
4. All participants received the same ten minute treatment with the ThermoStim.
5. Participants in the control group received the ten minute ThermoStim treatment without superficial heat.
6. Participants in the experimental group received the ten minute ThermoStim treatment with superficial heat at a setting of five.
7. Both groups were unaware of a second group in the study.

CHAPTER 2. LITERATURE REVIEW

The purpose of this study was to determine if the range of motion of the hamstrings muscle group could be increased utilizing instrument assisted soft tissue mobilization (IASTM) through the Dynatronics ThermoStim probe. This study also determined whether performing IASTM with simultaneous superficial heat through the Dynatronics ThermoStim probe could create greater range of motion than IASTM alone. In addition, both groups completed a survey post-intervention to determine whether superficial heat had an effect on patient comfort.

This study was guided by the following research questions: 1) Does instrument assisted soft tissue mobilization using Dynatronics ThermoStim increase range of motion for tight hamstrings, and if so, by how many degrees? 2) Does utilizing superficial heat on the ThermoStim probe with IASTM cause greater increases in range of motion than ThermoStim alone? and 3) Does using superficial heat with IASTM through the ThermoStim probe increase participant comfort during treatment? The hypothesis was that IASTM would create greater range of motion, and including superficial heat would create even greater range of motion than IASTM alone. Additionally, the inclusion of superficial heat during treatment would increase perceived patient comfort.

This literature review is about the effects IASTM and superficial heat have on range of motion of the hamstrings muscle group and perceived patient comfort. Since the Dynatronics ThermoStim is capable of both IASTM and superficial heat, these two aspects will be discussed in separate sections. The ThermoStim is also capable of simultaneously performing superficial cold and electrical stimulation. However, they will not be included in this literature review because these settings were not utilized in this study. This literature review is organized as follows: massage, IASTM, Graston technique®, ASTYM®, superficial heat, Dynatronics ThermoStim, and summary.

Massage

Smith, Sullivan, & Baxter (2010) define massage as "the use of the hands to physically manipulate the body's soft tissues for the purpose of effecting a desirable change in the individual" (p. 45). The American Massage Therapy Association (2009) describes a massage therapist as a practitioner who applies manual, manipulative techniques to the body with the intention of positively affecting the health and well-being of the client. In New Zealand, massage therapists stress the importance of addressing the physical, psychological, and emotional needs of clients in order to achieve mind and body balance; it is a holistic approach to healthcare instead of being seen as a modality that is applied to the body (Smith, Sullivan, & Baxter, 2010).

History of Massage

Instrument assisted soft tissue mobilization grew from what began as massage techniques that used a therapist's hands, fists, and long bones and was widely used in Asia, Northern Africa and Eastern Europe, specifically in China, Egypt, and Greece (Smith, Sullivan, & Baxter, 2010). Starkey (2004) dates massage techniques back to the ancient Olympians.

Fan (2006) examined the history of massage in Chinese medicine and found that massage was mentioned, though vaguely, in *The Yellow Emperor's Internal Classic*, the oldest known Chinese medicine book. This book dates between 2600 BC and 300 BC and was written by the emperor Huangdi, with the help of his personal physician (Fan, 2006). In Chinese medicine, massage and physical activity are so closely linked that they are combined into a single word: daoyin, or motion exercise (Fan, 2006). The Chinese believed that massage helped to maintain good health and prevent disease, therefore, massage therapy became an official part of medical training around 600 AD. This belief of applying pressure to areas of the body to refresh the qi and encourage better circulation, continues today (Fan, 2006).

As the idea of massage therapy techniques began spreading in the East, signs of massage were also beginning to show up in other areas of the world. Smith, Sullivan, & Baxter (2010) reported that the history of massage in Egypt dates from 2330 BC, with hieroglyphics showing therapists performing foot massages and reflexology. Even more recently and widespread, Hippocrates, a Greek physician born in 460 BC, was a large proponent of what he called anatripsis, or "to rub up." In his medical textbooks, he wrote that this technique helped to "bind a joint that was too loose or to loosen a joint that is too hard" (Smith, Sullivan, & Baxter, 2010, p. 44). These ancient societies tended to embrace massage as a medical procedure. On the other hand, Western medicine attributed massage as a magic trick until the 1880s when Swedish massage began to appear in nursing journals (Smith, Sullivan, & Baxter, 2010). By 1992, massage therapy became an independent medical treatment, separate from physiotherapy (Smith, Sullivan, & Baxter, 2010). Currently, worldwide massage certificates range from a six month program in relaxation massage to a three year Bachelor's degree in therapeutic and sports massage.

Benefits and Contraindications of Massage

Massage can promote a host of physiological changes in the body, and can have varying effects depending on the depth of tissues targeted. According to Starkey (2004), deep, vigorous massage can promote increased blood flow, temperature, and muscle excitation, while superficial massage may lead to relaxation. Other physiological benefits noted by Starkey include edema reduction through venous or lymphatic return and pain control by controlling muscle spasm or activating sensory nerves. Psychological changes in the patient can also occur as secondary effects of massage; many patients report reduced symptoms of anxiety, depression, and stress, leading to greater patient compliance (Starkey, 2004). Results from Smith, Sullivan, & Baxter (2010) also show patient reported benefits that include increased relaxation, increased alertness, increased pain threshold, and reduced symptoms of stress, anxiety, and depression due to a reduction in muscle tension and blood pressure.

While patients report a perceived increased sense of well-being from massage therapy, studies with physiological outcomes showed mixed results from massage techniques. Some results reported increased blood flow through superficial capillaries, while others have stated there was no change (Hemmings, 2001). Starkey (2004) stated that massage applied to the forearm and quadriceps area showed no increase in blood supply to the muscles. However, Weinberg, et al. (1988) reported that systolic stroke volume, red blood cell counts, and blood flow were all increased after a 30 minute full body Swedish massage, which the researchers considered a standard treatment. Weinberg et al. (1988) reported tissues were more extensible post-treatment. In addition, Moraska (2005) stated that a massage therapist can stretch muscle and fascia by changing the depth and speed of any stroke during a massage. Another benefit associated with massage is increased relaxation post-treatment. In theory, this is caused by decreasing the symptoms of delayed onset muscle soreness (DOMS) and decreasing neural arousal leading to a calmer overall physical state. Weinberg, et al. (1988) also found a positive correlation between massage and patient reported mood after therapy. Participants in this study rated themselves as lower in tension, fatigue, anger, and had less symptoms of depression, while also experiencing increased concentration after massage treatments (Weinberg, et al., 1988).

Massage therapy treatments and research studies often use a technique known as Swedish massage, which consists of a combination of five massage strokes to penetrate to the tissues targeted. The five strokes used during a Swedish massage treatment are effleurage, petrissage, tapotement, vibration, and cross-friction (Hemmings, 2001). Effleurage is the most commonly used stroke in massage because it is used to warm up the body and the tissues that are to be treated. In effleurage, massage therapists follow the contour of the participant's body with their hands and can easily vary the depth and pressure used, depending on the location of the treatment area. Most often, effleurage strokes are used superficially to increase circulation and lymph flow back to the core of the body and can be used with sites of chronic edema (Moraska, 2005). While effleurage is used to warm up tissues, petrissage is a kneading technique used to lift and separate the skin, fascia, and muscle. Adhesions or scar tissue occurring between any of these tissues can be loosened and muscle soreness can be reduced through petrissage (Moraska, 2005). Petrissage encourages disposal of waste products in the muscle and assists with venous and lymphatic return (Starkey, 2004). The third and fourth strokes in Swedish massage are tapotement and vibration, both of which can be used to warm up and energize muscles prior to physical activity or to relax muscles and desensitize irritated nerve endings (Starkey, 2004; Moraska, 2005). Tapotement is also known as a percussive stroke since the skin is lightly struck by cupped hands or long bones, while vibration is caused by a flat surface of the practitioner's body placed on the targeted tissue and moved at a rapid rate (vibrated) in a small treatment area (Moraska, 2005).

The final Swedish massage stroke is cross-friction, also called deep transverse friction massage, which is performed transversely or perpendicular to fibers (Moraska, 2005; Papa, 2012). Applying pressure to fibers in a transverse direction can produce physiological changes in collagen structures (Loghmani & Warden, 2009). Cross-friction is different from the other four strokes in that the clinician's hands never break contact with the tissues being treated, and typically focus on a very small treatment area, like a ligament, trigger point, or tendinous attachment. The basis of cross-friction was explored by Dr. James Cyriax in relation to the theory that fibroblastic activity occurs in the tissues after causing microtrauma (Chamberlain, 1982). In Chamberlain's 1982 study, cross friction massage was found to create greater range of motion when applied to musculoskeletal structures. The study showed that cross-friction massage created traumatic hyperemia, which means more blood was flowing to the treated tissue due to the damage caused by the treatment. This caused an increase in fibroblasts at the site, which helped to create greater production of matrix fibers to heal the damaged tissue in a more aligned manner (Loghmani & Warden, 2009). According to Starkey (2004), massage therapy including petrissage and cross-friction strokes can increase hamstring flexibility.

While massage therapy has shown promising results in promoting the healing of musculoskeletal injuries, there are several concerns and contraindications that clinicians must be aware of prior to treating a patient. Acute injuries or injuries in the inflammation phase, such as a sprain, fracture, or dislocation cannot be treated with massage (Starkey, 2004). Treating an acute injury could lead to an increase in inflammation or swelling at the injury site; swelling due to organ failure of the kidneys or cardiovascular system is also contraindicated (Starkey, 2004). Infectious skin conditions like dermatitis should be avoided, as well as any area with possible cellulitis (Starkey, 2004). Any recent skin injuries or burns are cause for concern, as is deep vein thrombosis because a massage could loosen a clot which could then travel to the lungs or brain (Smith, Sullivan, & Baxter, 2010; Starkey, 2004). A final precaution is to be aware of areas of decreased sensation and to decrease the pressure of the massage near those areas to avoid damage (Starkey, 2004). When treating patients, massage therapists must also be concerned about the effects massage can have on their body, specifically the stress put on the hands and wrists of the massage therapist. Clinicians are especially prone to developing carpal tunnel syndrome after prolonged cross friction massage without tools (Hammer, 2008).

Instrument Assisted Soft Tissue Mobilization

While soft tissue mobilization, or massage, is performed with a clinician's hands, instruments began being utilized in order to create greater pressure and torque on the treatment area while reducing the damage to the clinician's hands. Instrument assisted soft tissue mobilization (IASTM) is defined as using hard edged tools, with several different beveled edges, to assist in mobilization of musculoskeletal structures, such as tendons, ligaments, or muscles (Howitt, Jung, & Hammonds, 2009; Loghmani & Warden, 2009; Papa, 2012). Hyde & Gengenbach (2007) stated that soft tissue therapy helps to mobilize tissues post-injury to reduce adhesions, promote appropriate scar tissue formation, remove waste by-products from the injury site, improve circulation and lymphatic drainage, and improve range of motion of muscle and fascia. Currently, instruments range from more pliable materials like wood and plastic to heavy duty tools made of ceramic, aluminum, or stainless steel. The use of instruments in mobilizing tissues dates back to ancient Greek and Roman times, when they used wood and metal instruments to scrape dirt, wounds, and adhesions from the skin (Hammer, 2008).

Benefits of Instrument Assisted Soft Tissue Mobilization

Instrument assisted soft tissue mobilization (IASTM) is thought to increase metabolism and promote tissue remodeling in the tissues receiving treatment (Miners & Bougie, 2011; Papa, 2012). According to Hyde & Gengenbach (2007), there are three types of soft tissues that cause pain: 1) ligaments, 2) muscle, tendon, and fascia, and 3) neural structures; all of which can be treated with IASTM. Muscle strains, tendinopathies, and ligament sprains tend to be the most studied tissues involving IASTM treatments, though many other conditions are treated with IASTM. When treated with IASTM, patients with carpal tunnel syndrome, patellar tendonitis, and those diagnosed with chronic ankle sprains reported reduced symptoms of pain (Loghmani & Warden, 2009). Conditions such as muscle adhesions, scar tissue, fibromyalgia, muscular lumbar back pain, de Quervain's syndrome, and pain due to fractures of the long bones may also benefit from soft tissue mobilization (Hammer, 2008; Howitt, Wong, & Zabukovec, 2006; Papa, 2012).

In Eastern medicine, practitioners and acupuncturists perform a type of soft tissue mobilization with ceramic instruments, called gua sha, which is thought to increase metabolism in the tissues targeted (Hammer, 2008). In Chinese, gua sha means scraping or scratching and red rash, which is correlated to petechiae (Nielson, 2009). Petechiae is the formation of flat, round, red spots under the skin, which indicates bleeding between the dermal layers of the skin (Starkey, 2004). Practitioners use the ceramic instruments to target musculoskeletal pain by applying massage strokes in a repetitive, unidirectional manner for five to seven minutes or until petechiae forms. Since gua sha is thought to increase superficial perfusion, it has been utilized to assist in decreasing acute and chronic edema, as well as treating respiratory problems like bronchitis and emphysema. Sandberg, et al. (2003) achieved a 75% increase in superficial perfusion by performing acupuncture, compared to gua sha, which achieved a 400% increase in superficial perfusion at 7.5 minutes post-treatment and at 25 minutes post-treatment. In Nielson's (2009) pilot study, gua sha was performed on participants' back muscles and superficial tissue perfusion was recorded using laser Doppler imaging. Nielson's (2009) study showed that participants had reduced back pain and inflammation, which was attributed to the increase in microcirculation.

Furthermore, Braun et al. (2011) conducted a study performing gua sha on participants with chronic neck pain and randomly assigned them to groups receiving one treatment of either gua sha or a heat pad with ginger on their upper back and cervical spine. According to these researchers, ginger is seen as an equal, complementary treatment to gua sha. After one week, the group that received the gua sha treatment had a statistically significant decrease in pain, measured by the visual analog scale (VAS), while the group that received the heating pad did not (Braun, et al., 2001). Gua sha also showed a clinically significant increase in quality of life and overall perception of health for the participants, which was measured by the Short-Form [36] Health Survey. Physical function had a statistically significant increase and was measured by the Neck Disability Index (NDI), and due to these results, the participants in the gua sha group also rated their satisfaction with treatment much higher than the control group (Braun, et al., 2011).

Instrument assisted soft tissue mobilization (IASTM) has also been utilized for its ability to promote tissue remodeling, having shown to be beneficial for creating greater tensile strength in non-surgical ligamentous injuries (Loghmani & Warden, 2009; Loghmani & Warden, 2013). Loghmani & Warden (2013) examined bilateral medial collateral ligament (MCL) injuries induced in Sprague-Dawley rats and the effects Graston treatment had on the injury. One knee was used as a control, while the other was treated three times a week for three weeks with IASTM using a Graston Technique® instrument. While there was no immediate change in perfusion bilaterally, assessments taken 24 hours post-treatment on the 4th and 9th treatments showed significantly increased perfusion on the limb that was treated with IASTM. This increase was sustained until one week after the final treatment (Loghmani & Warden, 2013). Because IASTM did not cause an immediate increase in perfusion but showed results long after treatment had ceased, the researchers determined that the perfusion was not caused by vasodilation, but due to an increase in the number of small blood vessels in the region. An increase in the microvascularity of an injured area leads to greater healing due to the nutrients becoming more readily available to heal damaged tissue (Loghmani & Warden, 2013).

Instrument assisted soft tissue mobilization (IASTM) is not a treatment that can be used at any time, with any condition. Certain circumstances warrant vigilance and caution when applying IASTM to tissues, as well as conditions that would make a participant unable to continue treatment. The contraindications of IASTM are very similar to many other therapeutic modalities. According to Hammer (2008), skin must be intact, therefore soft tissue mobilization cannot occur over any open wounds, lacerations, abrasions, or fresh suture sites. Other contraindications include thrombophlebitis, hypertension, kidney disorders, hematoma, osteomyelitis, and myositis ossificans. Patient intolerance to increased pressure could cause a clinician to terminate treatment early or discontinue use altogether.

Many of the contraindications and precautions of IASTM are the same as those with massage, however, due to the aggressive nature of IASTM, there are added concerns. Any patient taking medications for anti-coagulation or blood thinners should be monitored closely post-treatment due to the risk of bleeding. Patients with cancer, varicose veins, rheumatoid arthritis and any acute or infectious condition should be treated with IASTM as a last resort; then proceed with caution and monitor post-treatment if warranted. These conditions can cause increased bruising, bleeding, and inflammation. Scars from burns, whether electrical, chemical, or otherwise, should be treated with IASTM in extreme caution (Hammer, 2008).

Graston Technique®

Graston Technique® is a mixture of cross-friction massage and IASTM, and is a commonly studied example of IASTM. Graston Technique® attempts to create controlled microtrauma to soft tissues with mechanical force (Papa, 2012; Miners & Bougie, 2011). Howitt, Jung, & Hammonds (2009) stated that the purpose of Graston Technique® is to restore muscular function by reducing adhesions and increasing circulation to the muscle. The instruments used to perform Graston Technique® were initially made of wood, then aluminum, and currently uses instruments made of surgical stainless steel (Hammer, 2008). There are six differently shaped tools used, GT-1 through GT-6, with varying concave and convex treatment surfaces to stress tissues in the body in different ways. These instruments are held at a 30-60° angle, depending on the amount of pressure needed to target a very small area, or scan a very large area (Hammer, 2008; Howitt, Jung, & Hammonds, 2009; Howitt, Wong, & Zabukovec, 2006). Intensity can be increased by using smaller instruments or treatment surfaces, faster or longer strokes, longer treatment times, or using an increased angle (60-90°) on the instruments. Likewise, more conservative treatments can be performed by using larger instruments or treatment surfaces, slower or shorter strokes, shorter treatment times, or decreased instrument angles (30-60°) (Carey-Loghmani, Schrader, & Hammer, 2015).

The Graston Technique® provider's manual (Carey-Loghmani, Schrader, & Hammer, 2015) explains the treatment edges and uses of each instrument. Used to treat large regions of the body, the GT-1 instrument (Appendix A) has a concave, single bevel treatment surface with two convex knobs. The concave surface of the instrument is used to scan, sweep, fan, swivel, or scoop tissues, while the knobs can treat trigger points. Conversely, the GT-2 instrument (Appendix A), used for very small areas of the body, is irregularly shaped and has several treatment surfaces: two convex knobs, one concave single beveled edge, and one concave double beveled edge. Scanning, sweeping, fanning, swiveling, and scooping can all be performed with the GT-2 instrument. Small, localized treatments can also be performed using the GT-3 instrument (Appendix A) which features a single bevel, convex treatment surface. It is used to brush, strum, or J-stroke areas along the vertebral column and patellar tendon. A more aggressive instrument, GT-4 (Appendix A) is used to create greater intensity in the treatment area due to its single bevel convex treatment surface. This instrument is used to scan, sweep, and fan large areas like the quadriceps or hamstrings, due to the ability to reach into the deeper fibers of these muscles. The GT-5 instrument (Appendix A) is a more conservative option to the GT-4, in that it has a single bevel concave treatment surface, leading to decreased pressure in the treated tissues. It is used to scan, sweep, fan, swivel, and scoop, and was specifically created to fit into the intercostal region of the body. Similar to the GT-2 instrument, the GT-6 instrument (Appendix A) is an irregular shape, but is smaller than the GT-2, and is often used to treat carpal tunnel syndrome and interdigital tissues. Due to the irregular shape and plethora of treatment edges, the GT-6 can sweep, scoop, brush, strum, or J-stroke using one knob, one hook, a single beveled concave edge, or a double beveled concave edge (Carey-Loghmani, Schrader, & Hammer, 2015).

A clinician scans the treatment area with an appropriately sized instrument to find adhesions or restrictions, then begins using one of seven strokes: sweep, fan, brush, strum, J-stroke, swivel, or scoop. The first stroke is the sweep stroke, which can be performed using any instrument except the GT-3, and involves moving the instrument in a linear direction. Fanning, or pivoting around one point, can be performed using the GT-1, GT-4, or G-5 instrument. Next, the brush, strum, and J-stroke are only performed using the GT-3 instrument. Brushing is a short stroke, used with light pressure to desensitize a painful or stimulated treatment area. Likewise, the strum is another short stroke, however, it is performed in a transverse direction, and is very similar to cross-friction massage. Unlike brushing, strumming uses increased pressure and can be very intense. The final stroke using the GT-3 instrument is the J-stroke, which can release adhesions between tissues or bony structures, and is made by making a 'J' in the tissue. The sixth stroke is the swivel stroke, in which the instrument doesn't move across tissues, but is set in one place and wiggled (swiveled) back and forth. Swiveling can be performed with either the GT-1, GT-2, or GT-6 instrument. Scooping, the last stroke, is performed using the GT-1, G-2, GT-5, or GT-6 instrument. The instrument begins at 90° perpendicular to the treatment tissue, then the tissue is scooped and the instrument ends at 30°. Finally, framing is a technique performed within any stroke, and is used to outline (frame) any bony prominence in the treatment area. Framing is most often performed with GT-2 or GT-3.

Graston Technique® Protocol

According to the Graston Technique® manual (Carey-Loghmani, Schrader, & Hammer, 2015), there is a standard protocol to follow when employing Graston Technique®, however, providers are also given freedom to use their clinical judgement for each treatment. Treatments are provided two to three times per week, to allow for bruising, petechiae, or swelling to diminish between treatments. When beginning a treatment session, patients undergo a three to five minute warm up, whether through superficial moist hot packs, ultrasound, or cardiovascular exercise. The clinician typically begins treatment by scanning to continue warming up the tissues to be treated, meanwhile searching for adhesions or crepitus. Instrument choices for scanning are usually guided by the shape and treatment surface of the instrument, as well as the shape and size of the tissue or body region to be treated. Treatment sessions lasts eight to ten minutes, including approximately one minute spent on the targeted tissue, and three to five minutes of treatment on the region around the tissue. For instance, if a clinician wants to target the supraspinatus muscle in the shoulder, the tendon would receive one minute of treatment, while the shoulder girdle would receive three to five minutes, and the entire upper extremity would be treated within eight to ten minutes (Hammer, 2008).

The Graston Technique® protocol includes stretching, strengthening, and cryotherapy post IASTM treatment in order to assist with healing and comfort. The stretching consists of multiple repetitions of thirty second stretches through the range of motion, followed by isometric stretches, also known as static stretching, in which the muscles are contracted without movement. Strengthening should be performed using low weight and high repetition. This is typically done using thera-band or exercise tubing in order to perform two or more sets of 15+ repetitions to increase muscular endurance. If used, cryotherapy after treatment can help minimize the risk of bruising, swelling, and muscle soreness (Hammer, 2008).

Effects of Graston Technique®

The studies performed on Graston Technique® have been limited, but of those conducted, many have shown significant results. Several case studies (Howitt, S., Wong, J., & Zabukovec, S., 2006; Miners & Bougie, 2011; Papa, 2012) reported that utilizing Graston Technique® on soft tissue led to an increase in range of motion for trigger thumb, Achilles tendinopathy, and De Quervain's. While those studies were performed on humans, Loghmani & Warden (2009) examined laboratory rats who underwent surgical repair bilaterally of their medial collateral ligaments on their hind legs. After surgery, one limb was used as a control, while the other received the experimental treatment of Graston Technique®. The ligaments were then removed and mechanically tested. The results showed that the ligaments treated with Graston Technique® were 43% stronger and could withstand 57% more pressure and energy than the contralateral side (Loghmani & Warden, 2009).

Hammer (2008) theorized that this increase in tensile strength was attributed to causing a controlled inflammatory response in the damaged tissue that lead to an influx of increased nutrients, prostaglandins, and cyclooxygenase. A recent randomized controlled study using Graston Technique® on the hamstrings to increase range of motion (Nejo, et al., 2014) showed promising results. Participants included men and women who ranged from physically inactive to well-trained athletes; neither gender nor activity level had any effect on the results. Researchers examined whether differences existed between a sham treatment, hot pack and Graston Technique® treatment, or a group that received a hot pack, Graston Technique® treatment, stretching, and strengthening. The results showed that the latter two groups both showed significant increases in range of motion post-intervention, averaging between 4° and 22° increase, but the sham group did not (Nejo, et al., 2014).

While the research on Graston Technique® is growing and results are showing promise, there is still some hesitation for healthcare practitioners to use Graston Technique®. To become a Graston Technique® M1 provider, a clinician must attend 12.5 hours of training; there is an additional fourteen hours of training necessary to complete the M2 course to become certified in Graston Technique®. This time, the cost required to attend the course and purchase the instruments is often out of reach for some practitioners. Another pitfall in using Graston Technique®, and IASTM in general, is a decrease in patient comfort during treatment. Bruising should not occur from treatment, but is a common consequence, due to the damage that occurs from microtrauma of treatment and breakdown of damaged tissue. Bruising typically disappears within three days. Research by Hammer (2008) reported that those who bruise during or after treatment typically respond better to the treatment and heal faster clinically.

ASTYM®

Like Graston Technique®, ASTYM® is an instrument assisted soft tissue treatment used to locate soft tissue abnormalities. Unlike Graston Technique®, ASTYM® treats tissues with pressure in a longitudinal manner, except near a bony prominence, then cross-friction treatments will take place (McCormack, 2012). One significant difference between IASTM and ASTYM® is that while IASTM is creating mechanical changes to the tissues treated, ASTYM® is trying to create chemical changes, specifically increases in vascular endothelial growth factor, for tendinopathies or degenerative conditions (T. Sevier, personal communication, January 6, 2016). According to Performance Dynamics, the company responsible for ASTYM®, the treatment began with the need to heal and regenerate soft tissues. Animal studies have shown that this healing occurred due to increased fibroblastic activity, lymphatic drainage and microcirculation (McCormack, 2012; Gehlsen, Ganion, & Helfst, 1999). The standard treatment protocol for ASTYM® calls for treating the region of the body that is injured, not just the injury site, then reassessing movement patterns and including functional exercises to return to activities of daily living. Over ten thousand participants were involved in studies leading up to the presentation of the ASTYM® system, which specializes in slowing the degeneration of tendinopathies by stimulating resorption of scar tissue, fibrosis, and regenerating soft tissues (Performance Dynamics, Muncie, IN, USA, 2014). In animal studies, ASTYM® treatments led to improvement in the repair of tendons and an increase in limb function through increased fibroblastic activity (Davidson, et al., 1997; Gehlsen, Ganion, & Helfst, 1999). In case studies involving humans, ASTYM® has been found to reduce pain and increase range of motion when scar tissue or soft tissue mobility are the limiting factors (Slaven & Mathers, 2011).

Outcomes for ASTYM® treatments can be categorized by six different criteria, including pain reduction, functional status, pain and functional improvement, patient satisfaction, and patient goals. For minor traumas, such as a sprain or a strain, ASTYM® led to a 93.4% functional improvement after eight treatments, while injuries like a repetitive stress improved 91.9% after nine treatments (Performance Dynamics, Muncie, IN, USA, 2014). For a hamstring strain, eight treatments were performed, leading to a 97.2% increase in functional activity (Performance Dynamics, Muncie, IN, USA, 2014).

Superficial Heat

Athletes are beginning to realize the benefits of increased flexibility and proper warm up prior to physical activity. Often times, athletes use superficial heating (thermotherapy) modalities to prepare muscles, tendons, ligaments, or fascia for activity; heat is also indicated for injuries involving decreased range of motion and in the sub-acute and chronic phases (Starkey, 2004). While there are a variety of thermotherapy modalities, the most commonly used treatments are warm whirlpools, active exercise, ultrasound, and moist hot packs (Hanson & Day, 2012). Knight, et al. (2001) stated that superficial heating combined with stretching showed statistically significant improvements in hip range of motion. According to Starkey (2004), applying heat can reduce muscle spasm and decrease pain by stimulating nerve fibers, which then blocks the transmission of pain sensations. However, this nerve blocking only lasts as long as the superficial heat is applied to tissues.

An efficient way to heat muscles prior to activity is by creating warm up programs. Hanson & Day (2012) showed that active exercise, such as a warm up prior to competition, created the greatest increase in temperature (3.8° Fahrenheit) when compared to warm whirlpools or moist hot packs (1.4-1.6° Fahrenheit); active exercise may also be the easiest due to the equipment needed for other interventions. In this study, females had greater range of motion prior to the thermotherapy intervention, but showed the greatest increases in range of motion post-intervention, which were statistically significant. The researchers attributed this increase in range of motion due to an increase in local blood flow, which led to increased tissue extensibility. Superficial heat also decreased muscular excitability and participants reported lower pain ratings. While range of motion was increased, the researchers reported superficial heating only penetrated up to two centimeters deep to the skin, so deeper muscles may not experience the same range of motion increases (Hanson & Day, 2012). Starkey (2004) stated although superficial heating only reached 2 centimeters in depth, the therapeutic effects may last up to 30 minutes or longer.

Moist Hot Packs

A readily available way to heat superficial tissues is through the use of moist hot packs, a silica filled canvas pouch that absorbs water to retain heat during treatments. Moist hot packs range in temperatures from 160-166° Fahrenheit and retain therapeutic temperature for up to 45 minutes post-treatment (Starkey, 2004). Starkey (2004) reports that application of a moist hot pack can increase hamstring range of motion more than stretching, but this is due to muscle relaxation, not tissue elongation. Most often, moist hot packs need to be combined with other modalities, such as IASTM, in order to increase tissue elongation. Lin (2003) reported that moist hot packs raised local tissue temperature enough to increase range of motion, by reducing the friction between tissues, such as a tendon sheath or between muscle and fascia. Lin (2003) also reported that superficial heating caused a decrease in musculoskeletal pain, but noted that heat is not a substitute for a topical anesthetic. Knight, et al. (2001) also reported increases in range of motion from the use of moist hot packs. Participants in this six-week study followed a stretching protocol and used a moist hot pack for fifteen minutes three times per week on the same muscles on the plantar surface of the foot. Moist hot packs were compared to active exercise and a control group. At the end of the study, the control group had experienced no change in passive or active range of motion. However, participants who used moist hot packs or active exercise to warm up and then performed the stretching protocol increased their range of motion by an average of 4.38°, while the average passive range of motion increased by 4.90°.

Not only can the use of moist hot packs increase range of motion, but, as stated by Lin (2003), moist hot packs can also decrease musculoskeletal pain. A recent study on superficial moist hot packs had participants using moist hot packs at temperatures between 105-115° Fahrenheit every other day for 20 minutes (Yildirim, et al., 2010). Overall, participants' pain ratings decreased and general health scores and physical functioning increased. Khamwong, et al. (2011) was also interested in the effect superficial heat had on symptoms of musculoskeletal pain; the researchers examined the effects of prophylactic superficial heat on the damage caused in wrist extensors by eccentric exercise. The researchers noted that superficial and deep heating were effective in reducing the symptoms of muscle damage by increasing the skin temperature 40-45° Celsius and the underlying muscle temperature 1-3° Celsius. The participants in the Khamwong, et al. (2011) study received a moist hot pack treatment for 20 minutes over the wrist extensors of the non-dominant arm, performed eccentric exercise, then were reassessed once a day for eight days for passive range of motion, active range of motion, and pain threshold. Though there were no significant differences in pain intensity between groups, the decreases in range of motion for active wrist extension and passive wrist flexion and extension was significantly smaller for the group that received the prophylactic hot pack. As these studies support heating superficial tissues through the use of moist hot packs can not only increase range of motion and cause muscle relaxation, but can also decrease symptoms of pain. However, as Starkey (2004) stated, increased range of motion only occurs with superficial heating due to muscle relaxation and not tissue elongation. To create greater range of motion that has the ability to be maintained after tissues cool, other modalities must also be used.

Dynatronics ThermoStim

At the National Athletic Trainers' Association symposium in 2012, Dynatronics, a well-known sports medicine modality company, introduced a new product: the ThermoStim probe. This handheld probe boasts three different metal edges and two corners and attaches to the SolarisPlus unit (Dynatronics, 2012). This combination can assist a clinician with IASTM by providing several tools in one. With the SolarisPlus unit and the ThermoStim probe, combinations of IASTM, electrical stimulation, superficial heat, and superficial cold are possible (PR, N. (2014, February 14)). This helps to limit treatment times by applying several modalities to an athlete at one time, which in turn, claims to increase patient tolerance and compliance (PR, N. (2014, February 14)).

The ThermoStim probe, unlike other IASTM treatments, does not come with a specific treatment protocol, nor does the practitioner need to be trained or certified to use it. Dynatronics relies on the practitioner to make clinical decisions about each patient's treatment protocol; however, this can lead to issues when a patient is treated by many different practitioners. Massage is also not regulated in many countries, meaning that treatments can vary widely and practitioners may not be trained at all (Smith, Sullivan, & Baxter, 2010).

Parameters

The ThermoStim has ten temperature settings, ranging from 39°F to 112°F and can achieve those temperatures from room temperature within sixty seconds (Dynatronics, 2012). Guffey, et al. (2013) performed the only study thus far on the ThermoStim, which assessed the pain and function of plantar fasciitis on patients who were treated with light therapy. The goal of this study was to determine if red and infrared light could provide additional improvements in the outcome of patients using the most typical treatments for plantar fasciitis. Plantar fasciitis is a painful condition of inflammation and degeneration of the plantar aponeurosis of the foot, most noted when taking the first steps out of bed in the morning. According to Guffey, et al. (2013), plantar fasciitis is the most common condition seen in physical therapy clinics in the United States, due to two million Americans suffering from it each year.

The participants were randomly assigned to two groups (Guffey et al., 2013). All participants received heat, electrical stimulation, and soft tissue mobilization using the ThermoStim probe, while post-intervention stretching protocols were also implemented. The experimental group received combination light therapy in addition to the previously mentioned modalities. Participants received a total of eight treatments in four weeks, with pre- and post-test measurements of the Visual Analog Scale and Foot Function Index. Participants performed daily stretching routines including a wall stretch for the Achilles tendon (4x30 seconds), a seated stretch of the gastrocnemius and soleus (4x30 seconds) and a massage of the bottom of the foot using a bottle or a ball (3-5 minutes). The participants then received biphasic electrical stimulation at five pulses per second with 250 microseconds pulse duration. Electrical stimulation was set at maximum sensory level comfort without a contraction of the treated muscles. Electrical stimulation, superficial heating, and soft tissue mobilization were simultaneously delivered through the ThermoStim probe for 15 minutes. Parameters for soft tissue mobilization were not included. Following the treatment, the experimental group received a combination of red (624nm) and infrared (850nm) light therapy, administered at 9 J/cm2 at three locations from proximal to distal on the planter fascia.

Both groups improved in function and decreased in pain, but the experimental group had statistically significant decrease in pain and improvement in function. The control group was not statistically significant for either, nor was the post treatment difference between the control and experimental group. Due to these results, Guffey, et al. (2013) determined that light could be beneficial when used in conjunction with other modalities, but not as a stand-alone treatment for plantar fasciitis.

Summary

Instrument assisted soft tissue mobilization (IASTM) is similar to massage in that it treats soft tissues of the body, but by using instruments that can create greater pressure and reach deeper tissues. IASTM treatments include the Graston Technique® and ASTYM®. While each of these have separate and specific protocols to follow for treatments, the Dynatronics ThermoStim does not have a treatment protocol and instead relies on the clinical abilities of the practitioner to determine treatment times and parameters. Graston Technique® and ASTYM® have both shown that treatments can increase the range of motion for participants; therefore, using the ThermoStim to perform IASTM should have comparable results when used on the hamstrings. Superficial heating has not only shown improvements in range of motion, but also decreases in symptoms of musculoskeletal pain. However, these improvements are related to muscle relaxation due to superficial heating; therefore, to create tissue elongation, superficial heating should be combined with another modality, such as IASTM. In this way, the ThermoStim is appropriately equipped to perform both IASTM and superficial heating at the same time, rather than having separate treatment times. When IASTM and superficial heat is performed through the ThermoStim probe on the hamstring muscle group, there should be an increase in range of motion as well as an increase in patient comfort.

CHAPTER 3. METHODS

The purpose of this study was to determine if the range of motion of the hamstrings muscle group could be increased utilizing instrument assisted soft tissue mobilization (IASTM) through the Dynatronics ThermoStim probe. This study also determined whether performing IASTM with simultaneous superficial heat through the Dynatronics ThermoStim probe could create greater range of motion than IASTM alone. In addition, both groups completed a survey post-intervention to determine whether superficial heat had an effect on patient comfort.

This study was guided by the following research questions: 1) Does instrument assisted soft tissue mobilization using Dynatronics ThermoStim increase range of motion for tight hamstrings, and if so, by how many degrees? 2) Does utilizing superficial heat on the ThermoStim probe with IASTM cause greater increases in range of motion than ThermoStim alone? and 3) Does using superficial heat with IASTM through the ThermoStim probe increase participant comfort during treatment? The hypothesis was that IASTM would increase range of motion, and the addition of superficial heat would create even greater range of motion than IASTM alone. Additionally, the inclusion of superficial heat during treatment would increase perceived patient comfort. This chapter focuses on participant demographic information, how participants were recruited, how this study was performed, and statistical analysis. It is organized into experimental design, participants, instruments for data collection, procedures, and data analysis.

Experimental Design

A pre-test, post-test design was used for this study, using measurements of the range of motion of the hamstrings muscle group and perceived patient comfort. Participants were assigned to one of two groups: (1) instrument assisted soft tissue mobilization (IASTM) without superficial heat or (2) instrument assisted soft tissue mobilization (IASTM) with a superficial heat setting of five. Both groups received the same IASTM treatment, with the exception of the addition of superficial heat. The dependent variable was range of motion (ROM) and perceived patient comfort, and the independent variable was the type of treatment (IASTM with or without superficial heat). Participants received the same condition for both treatments, and all treatments were performed on the left leg of the participant.

Participants

Thirty college-aged men and women, 18-23 years old, were recruited to participate in this study, coming from a pool of intercollegiate athletes at a division III college in the mid-west. Participants had tight hamstrings, as defined by less than 70° passive knee extension with the hip flexed to 90°, and were pre-screened prior to the study. The left leg was used for all participants. This study was modeled after a previous similar study using the same inclusion criteria (Nejo, et al., 2014). Thirty to fifty participants were needed to have comparable results with Nejo et al, 2014. Participants were recruited through the student-athlete mailing list and word of mouth at the division III college.

Exclusion criteria included broken or damaged skin in the posterior legs, history of deep vein thrombosis, or history of abnormal lower extremity neurological condition. Participants were excluded if they had a history of a hamstring injury within the previous two months, or if they had lower extremity surgery within the previous six months. All participants signed an informed consent form in order to participate. North Dakota State University's Institutional Review Board approved this study.

Instruments for Data Collection

The Dynatronics ThermoStim probe (Dynatronics, Salt Lake City, UT) includes three beveled treatment edges (two long, one short) and two corners with which to perform instrument assisted soft tissue mobilization (Appendix A). The long edges were utilized in this study, due to the large area of the hamstring muscle group to be treated. The ThermoStim is able to simultaneously perform IASTM with electrical stimulation and cold and heat settings from 39-112° Fahrenheit. Electrical stimulation and cold settings were not used during this study. A superficial heat setting of five, which corresponds to approximately 112°F, was used along with IASTM for the experimental group. The ThermoStim probe was plugged into the machine, but not turned on during treatment for those in the control group. Sammons Preston multi-purpose ultrasound gel (Patterson Medical, Bolingbrook, IL) was used as an emollient for the IASTM treatment.

A BASELINE 360° goniometer (Fabrication Enterprises, White Plains, NY) was used to collect pre- and post-treatment range of motion measurements. The goniometer's fulcrum was placed at the lateral joint line of the knee, with the stationary arm in line with the greater trochanter of the femur, and the movable arm in line with the lateral malleolus of the ankle. A homemade measurement stand, made for a previous study by Nejo, et al. (2014), was loaned to the author for this study. Two PVC poles were set between the treatment table and a wall, with each pole being connected to a looped string (Appendix A). Participants completed a six question survey post-intervention (Appendix B), rating their level of knowledge of and comfort during the IASTM treatment. The survey also determined whether the participants felt a warming or heating effect from the superficial heat and whether that led to greater comfort during treatment.

Procedures

Prior to this study, participants were asked to maintain their lifestyles including their activity levels, but to avoid beginning any new stretching or exercise programs. When participants were recruited and signed informed consent, they were informed of the ThermoStim probe, instrument assisted soft tissue mobilization (IASTM) treatment, and that they may or may not feel a heating response with the treatment. Participants were unaware of a difference between groups. There was no attrition in this study; the participants were given an arbitrary identification number to use during the study, therefore no identifying information was connected to their data.

Range of motion prior to and after treatment was measured using the aforementioned set up. Two PVC poles were set between the treatment table and a wall, with each pole being connected to a looped string (Appendix A). Participants laid supine on the treatment table with their head near the wall and poles. The looped string was placed behind the knee with the participant's hip placed into 90° of flexion. The goniometer's fulcrum was placed at the lateral joint line of the knee, with the stationary arm in line with the greater trochanter of the femur, and the movable arm in line with the lateral malleolus of the ankle. The participant was instructed to relax and allow the researcher to passively extend his/her knee. Three measurements were taken and averaged for the pre-treatment range of motion. After assessing range of motion, the researcher performing IASTM measured six inches proximal from the lateral and medial joint line of the knee and marked this using washable markers. The researcher measured six inches distal from the ischial tuberosity and marked with washable markers. These were used as the borders of the treatment area.

Both groups received the same instrument assisted soft tissue mobilization (IASTM) treatment of ten minutes. Multi-purpose ultrasound gel (Patterson Medical, Bolingbrook, IL) was applied to the muscle belly of the hamstrings muscle group and spread to the proximal and distal attachments using the flat treatment surface of the ThermoStim probe. Then, the long treatment edge of the ThermoStim probe was held at 45° to the tissue and pressure was moderate. The primary researcher performed all IASTM treatments, and has performed gua sha for three years, is a Graston Technique® Provider, as well as utilized the ThermoStim probe clinically for three months. The first three minutes of the treatment consisted of large, sweeping strokes to the entire hamstring muscle group. The next two minutes focused on the distal six inches of the hamstrings attachment sites, near the posterior lateral and posterior medial knee. The following two minutes focused on the proximal six inches of the hamstring muscle group, near the ischial tuberosity. During the two minutes at the proximal and distal attachments, one minute was used to perform the strum stroke and one minute was used to perform the fan stroke. The final three minutes were used to sweep the entire hamstrings area again. The Dynatronics SolarisPlus has a countdown timer for treatments, which was used to determine changes in stroke and location of treatment. The experimental group received superficial heat at a setting of five during the treatment through the ThermoStim probe. The control group received no superficial heat during the treatment.

Each participant received the same treatment two times, with seventy-two hours between treatments. After the final treatment, range of motion was assessed using the pre-treatment set up. Three measurements were taken and averaged for the final range of motion assessment. Participants completed a six question survey (Appendix B) after both treatments, analyzing their familiarity with IASTM, comfort during treatment, and sensation of superficial heating.

Data Analysis

The mean of the pre- and post-treatment range of motion measurements was analyzed using a dependent t-test to determine differences between pre-treatment and post-treatment range of motion. Independent samples t-tests analyzed the range of motion differences between groups and for differences in perceived patient comfort between groups. Statistical analysis was performed using the IBM SPSS Statistics program version 24 (2016, IBM) at a significance level of $p < 0.01$.

CHAPTER 4. RESULTS

The purpose of this study was to determine if the range of motion of the hamstrings muscle group could be increased utilizing instrument assisted soft tissue mobilization (IASTM) through the Dynatronics ThermoStim probe. This study also determined whether performing IASTM with simultaneous superficial heat through the Dynatronics ThermoStim probe could create greater range of motion than IASTM alone. In addition, both groups completed a survey post-intervention to determine whether superficial heat had an effect on patient comfort.

This study was guided by the following research questions: 1) Does instrument assisted soft tissue mobilization using Dynatronics ThermoStim increase range of motion for tight hamstrings, and if so, by how many degrees? 2) Does utilizing superficial heat on the ThermoStim probe with IASTM cause greater increases in range of motion than ThermoStim alone? and 3) Does using superficial heat with IASTM through the ThermoStim probe increase participant comfort during treatment? The hypothesis was that IASTM will create greater range of motion, and including superficial heat will create even greater range of motion than IASTM alone. Additionally, the inclusion of superficial heat during treatment will increase perceived patient comfort. This chapter focuses on the results of the study and is organized into descriptive statistics, statistical results, and summary of the results.

Descriptive Statistics

Thirty NCAA Division III collegiate student-athletes were pre-screened for tight hamstrings, as defined by less than 70° of passive knee extension with the hip flexed to 90°. All 30 were found to have tight hamstrings and chose to participate; there were no drop outs in this study. Participants included 15 females and 15 males; 8 females and 8 males received superficial heat with IASTM, while 7 females and 7 males received only IASTM. The student-athletes consisted of 12 football players, 7 women's basketball players, four softball players, and one from each of the following sports: men's basketball, wrestling, baseball, men's track and field, women's hockey, women's soccer, and women's track and field. Participants ranged from 19 to 22 years of age, with a mean age of 20.27±1.015 years. Of these 30 participants, 12 were previously aware of IASTM but had never received it as a treatment option, 11 were unaware of IASTM, and 7 had received IASTM treatment and felt the treatment was beneficial. No participants had previously received IASTM treatment and felt it was not beneficial.

Statistical Results

Using a dependent t-test, there was a statistically significant increase in range of motion for all participants. For the first treatment, range of motion increased from 52.23±10.45° to 60.39±9.58° [t(29)= 8.365, $p < 0.01$], and from 55.58±7.31° to 66.23±6.77° [t(29)= 14.652, $p < 0.01$] for the second treatment. However, using an independent t-test, there was not a significant difference in range of motion between groups for the first or second treatment [t(28)=0.895, p = 0.471 and t(28)=0.377, p = 0.587, respectively] or the mean increase in range of motion (p = 0.795). For the first treatment, those who received superficial heat with IASTM saw a 7.28±5.91° increase in range of motion, while those who did not receive superficial heat with IASTM increased their range of motion by 9.05±4.78°. After the second treatment, participants who received superficial heat with IASTM gained 10.38±4.32° range of motion and those who didn't receive superficial heat with IASTM increased by 10.93±3.74°. Participants who received superficial heat with IASTM achieved a mean of 8.83±3.39° increase in range of motion, while those that did not receive superficial heat had a mean of 9.99±3.38° increase in range of motion (Table 1).

Table 1

Pre- and post-test range of motion of the hamstrings for all participants

	Pre-test ROM	Post-test ROM	*t*-statistic	*p* value
First Treatment	52.23±10.45°	60.39±9.58°	$t(29) = 8.365$	$p < 0.01$
Second Treatment	55.58±7.31°	66.23±6.77°	$t(29) = 14.652$	$p < 0.01$

Table 2

Range of motion increases by group using an independent t-test

	Mean ROM increase with superficial heat	Mean ROM increase without superficial heat	*t*-statistic	*p* value
First Treatment	7.28±5.91°	9.05±4.78°	$t(28)=0.895$	$p = 0.471$
Second Treatment	10.38±4.32°	10.93±3.74°	$t(28)=0.377$	$p = 0.587$
Mean ROM increase by group	8.83±3.39°	9.99±3.38°		$p = 0.795$

The mean range of motion increase for females for the first treatment was 7.96±4.59°, and was 8.38±6.18° for males. For the second treatment, the mean range of motion increase for females was 10.31±3.67° and 11.00±4.38° for males. The overall mean range of motion increase for females was 9.13±3.54° and was 9.69±3.31° for males (Table 2). Range of motion increases by gender were not statistically different for the first treatment [$t(28)=0.211$, $p = 0.990$], second treatment [$t(28)=0.468$, $p = 0.137$] or for mean range of motion increase [$t(28)=0.443$, $p = 0.385$].

Table 3

Mean range of motion increase by gender after first treatment, second treatment, and overall mean

	First Treatment	Second Treatment	Mean
Female	7.96±4.59°	10.31±3.67°	9.13±3.54°
Male	8.38±6.18°	11.00±4.38°	9.69±3.31°
t-statistic	*t*(28)=0.211	*t*(28)=0.468	*t*(28)=0.443
p value	$p = 0.990$	$p = 0.137$	$p = 0.385$

There also was no significant difference between groups for perceived patient comfort. Participants rated their comfort (1 = very uncomfortable, 2 = slightly uncomfortable, 3 = neutral, 4 = slightly comfortable, 5 = very comfortable) and the intensity of the warming or heating effect (1 = no warming or cooling effect felt, 2 = slightly cool, 3 = slightly warm, 4 = moderately warm, 5 = very warm). Participants who received superficial heat with IASTM rated their comfort during the two treatments at 3.80±1.37 ($p = 0.549$) and 3.93±1.22 ($p = 0.881$), while describing the warming or heating response as moderately warm (4.07±0.79 [$p = 0.231$] and 4.33±0.72 [$p = 0.016$], respectively). Participants who did not receive superficial heat with IASTM rated their comfort during the two treatments at 3.47±1.25 and 3.27±1.22, and described the warming or heating response as slightly to moderately warm (3.90±1.29 and 3.36±1.43, respectively) (Table 3).

Table 4

Perceived patient comfort ratings by group for each treatment

Condition	First Treatment	Second Treatment
Perceived Patient Comfort, Superficial Heat	3.80±1.37	3.93±1.22
Perceived Patient Comfort, No Heat	3.47±1.25	3.27±1.22
Heating or Warming Response, Superficial Heat	4.07±0.79	4.33±0.72
Heating or Warming Response, No Heat	3.90±1.29	3.36±1.43

Immediately after the first treatment, participants rated their comfort level for the IASTM treatment; 11 participants (36.67%) rated the treatment as very comfortable (5), 8 participants (26.67%) rated neutral (3), 5 (16.67%) rated slightly comfortable (4), four (13.33%) rated slightly uncomfortable (2), and two (6.67%) rated very uncomfortable (1). Twenty-five participants (83.33%) stated they experienced a warming or heating response, while five (16.67%) did not. Seventeen of the participants (68%) who experienced a warming or heating response rated it as slightly warm (3), while the remaining eight (32%) rated it as moderately warm (4). Nine participants (36%) rated the warming or heating response as very comfortable (5), 9 (36%) rated slightly comfortable (4), 6 (24%) rated neutral (3), and one (4%) rated very uncomfortable (1). After the first treatment, all 30 (100%) participants stated they would request IASTM as a treatment option in the future.

After the second treatment, 10 participants (33.33%) rated the IASTM treatment as very comfortable (5), 7 (23.33%) were neutral (3), 6 (20%) rated slightly comfortable (4), 6 (20%) rated slightly uncomfortable (2), and one (3.33%) rated very uncomfortable (1). Twenty-six participants (86.67%) felt a warming or heating response, while four (13.33%) did not. Seventeen (65.38%) of those participants who felt a warming or heating response rated it as slightly warm (3), while the remaining 9 (34.62%) rated it was moderately warm (4). The warming or heating response was very comfortable (5) for 9 participants (34.62%), slightly comfortable (4) for 11 (42.31%), neutral (3) for three (11.54%), very uncomfortable (1) for two (7.69%), and slightly uncomfortable (2) for one participant (3.85%). All 30 participants again stated they would request IASTM as a treatment option in the future.

Table 5

Comfort ratings for IASTM treatment for treatment sessions

Comfort Rating for IASTM Treatment	Number of Participants (Percentage of Participants) First Treatment	Number of Participants (Percentage of Participants) Second Treatment
5: Very Comfortable	11 (36.67%)	10 (33.33%)
4: Slightly Comfortable	5 (16.67%)	7 (23.33%)
3: Neutral	8 (26.67%)	6 (20%)
2: Slightly Uncomfortable	4 (13.33%)	6 (20%)
1: Very Uncomfortable	2 (6.67%)	1 (3.33%)

Summary of Results

The hypothesis that IASTM could increase range of motion of the hamstrings was supported by the data collected for this study. However, the hypotheses that superficial heat during IASTM treatment would create greater range of motion and perceived patient comfort than IASTM alone was not supported by the data in this study. In fact, according to this study, perceived patient comfort was higher in those who did not receive superficial heat during treatment. In addition, gender had no impact on the outcomes of this study.

CHAPTER 5. DISCUSSION

The purpose of this study was to determine if the range of motion of the hamstrings muscle group could be increased utilizing instrument assisted soft tissue mobilization (IASTM) through the Dynatronics ThermoStim probe. This study also determined whether performing IASTM with simultaneous superficial heat through the Dynatronics ThermoStim probe could create greater range of motion than IASTM alone. In addition, both groups completed a survey post-intervention to determine whether superficial heat had an effect on patient comfort.

This study was guided by the following research questions: 1) Does instrument assisted soft tissue mobilization using Dynatronics ThermoStim increase range of motion for tight hamstrings, and if so, by how many degrees? 2) Does utilizing superficial heat on the ThermoStim probe with IASTM cause greater increases in range of motion than ThermoStim alone? and 3) Does using superficial heat with IASTM through the ThermoStim probe increase participant comfort during treatment? The hypothesis was that IASTM will create greater range of motion, and including superficial heat will create even greater range of motion than IASTM alone. Additionally, the inclusion of superficial heat during treatment will increase perceived patient comfort. This chapter focuses on the discussion of the results of the study and is organized into discussion, recommendations for clinical utilization, limitations of study, recommendations for future research, and conclusion.

Discussion

This study used the ThermoStim probe, which has two long treatment edges and one short treatment edge; these edges are most similar to the GT-4 instrument used with the Graston Technique® protocol. The GT-4 has a single bevel, convex treatment edge which creates greater intensity in the target tissue. It is used to sweep and fan large areas like the quadriceps or hamstrings and can reach the deeper fibers of these muscles, which is why the hamstrings were chosen for the current study.

Graston Technique® protocol (Carey-Loghmani, Schrader, & Hammer, 2015) states that instruments should be held between 30-60° angle, with the former being more conservative and the latter being more aggressive (Hammer, 2008; Howitt, Jung, & Hammonds, 2009; Howitt, Wong, & Zabukovec, 2006). Intensity can be increased by using smaller instruments or treatment surfaces, faster or longer strokes, and longer treatment times. Likewise, more conservative treatments can be performed by using larger instruments or treatment surfaces, slower or shorter strokes, and shorter treatment times (Carey-Loghmani, Schrader, & Hammer, 2015). The current study used the long treatment edge of the ThermoStim probe with an angle of 45° to create a moderate pressure, combined with a ten minute standardized IASTM treatment. These factors combined should have created a moderate treatment suitable for all participants with healthy, but tight hamstrings.

The protocol used in this study was based on Graston Technique® guidelines (Carey-Loghmani, Schrader, & Hammer, 2015) and standardized so all participants received the same ten minute treatment. Prior to Graston Technique® treatments, patients are given a heating modality to warm up the target tissues; this is why the heat setting was utilized on the ThermoStim probe. After the application of superficial heat, a clinician sweeps or fans the treatment area to find adhesions or restrictions, then can use the strum stroke to decrease adhesions. Typically, Graston Technique® treatments are performed two to three times per week to allow for bruising and petechiae to diminish (Carey-Loghmani, Schrader, & Hammer, 2015). The current study performed two treatments 72 hours apart, in order for bruising or petechiae to resolve from the first treatment. Graston Technique® advises the use of cryotherapy post-treatment to control pain and swelling (Carey-Loghmani, Schrader, & Hammer, 2015), so participants in the current study were offered ice bags post-treatment as well.

The strokes used in this study were similar to, and used the terminology of, Graston Technique®. The most closely related massage strokes used were effleurage (sweeping), petrissage (fanning), and cross-friction (strumming) (Hemmings, 2001). Effleurage (sweeping) was used to warm up the tissues to be treated. Moraska (2005) attributes this to superficial increases in circulation and lymph flow back to the core of the body. Petrissage (fanning) is a kneading technique used to lift and separate the skin, fascia, and muscle, thereby decreasing adhesions or scar tissue occurring between any of these tissues (Moraska, 2005). The final stroke used was cross-friction (strumming), which is performed transversely or perpendicular to fibers (Moraska, 2005; Papa, 2012), without the treatment surface of the instrument breaking contact with the target tissues. Chamberlain (1982) reported cross friction massage created greater range of motion when applied to musculoskeletal structures, much like the current study. Chamberlain attributed this increased range of motion to increased blood flow in the treated tissues, creating stronger, more aligned matrix fibers; this is supported by the results of a study conducted by Loghmani & Warden (2009). Starkey (2004) also supports that massage therapy including petrissage and cross-friction strokes can increase hamstring flexibility.

The participants in this study significantly increased their hamstring range of motion after receiving IASTM treatment from the Dynatronics ThermoStim probe. The addition of superficial heat during IASTM treatment did not further increase hamstring range of motion, nor did it increase perceived patient comfort. According to Starkey (2004), deep, vigorous massage can promote increased tissue temperature, while superficial massage may lead to relaxation. The increased tissue temperature felt by the participants in this study could be due to the friction of the IASTM treatment, rather than the temperature setting on the ThermoStim probe. The increased range of motion could also be attributed to a combination of the increased temperature due to friction and from the relaxation due to the IASTM treatment. Starkey (2004) also noted that pain can be controlled by activating sensory nerves which could be correlated with the increased perceived patient comfort in this study. Participants in this study reported feeling relaxed and stated they would request this treatment again due to the comfort they felt during and after treatment, much like participants in a Smith, Sullivan, & Baxter (2010) study. Those participants reported benefits that included increased relaxation, increased pain threshold, and reduced symptoms of stress, anxiety, and depression which was correlated with a reduction in blood pressure and muscle tension. The current study did not measure those additional outcomes.

This study included a ten minute IASTM treatment for all participants with one group receiving superficial heat during this time and one group who did not receive superficial heat during treatment. A standard treatment time for a full body Swedish massage is 30 minutes (Weinberg, et al., 1988). Swedish massage is typically more conservative than IASTM which would explain the difference in treatment times. Weinberg, et al. (1988) conducted a study with all participants receiving a Swedish massage and reported increases in systolic stroke volume, red blood cell counts, and blood flow. These researchers also noted that the tissues that were massaged were more extensible post-treatment. This is supported by the Moraska (2005) study which stated muscle and fascia can be stretched by changing the depth and speed of any stroke during a massage. Participants in both Weinberg et al. (1988) and Moraska (2005) also reported increased relaxation and improved mood post-treatment which was also supported by the reports of the participants of this study.

Another possible reason for the increase in range of motion for the participants in this study is due to the decrease in adhesions in the target tissue, which is supported by the Hyde & Gengenbach (2007) study. These researchers reported that soft tissue therapy helped to mobilize tissues and increase range of motion in both muscle and fascia post-injury by reducing adhesions, promoting appropriate scar tissue formation, removing waste by-products from the injury site, and improving circulation and lymphatic drainage. The purpose of Graston Technique® is to restore muscular function by reducing adhesions and increasing circulation to the muscle (Howitt, Jung, & Hammonds, 2009). Several case studies (Howitt, S., Wong, J., & Zabukovec, S., 2006; Miners & Bougie, 2011; Papa, 2012) reported that utilizing Graston Technique® on soft tissue led to an increase in range of motion for trigger thumb, Achilles tendinopathy, and De Quervain's. A recent randomized controlled study used Graston Technique® on the hamstrings to increase range of motion (Nejo, et al., 2014) and reported increases similar to the current study. Participants differed between the two studies in that the previous study included men and women who ranged from physically inactive to well-trained athletes while the current study used Division III intercollegiate athletes; neither gender nor activity level had any effect on either study's results. Nejo et al. (2014) reported that the two groups who received Graston Technique®, with or without the stretching protocol, showed significant increases in range of motion post-intervention, averaging between 4° and 22° increase, but the sham group did not (Nejo, et al., 2014). Both groups in the current study had significant increases in range of motion, with gains of up to 21°; superficial heat had no effect on the results.

Another IASTM treatment program, ASTYM®, has been found to reduce pain and increase range of motion when scar tissue or soft tissue mobility are the limiting factors (Slaven & Mathers, 2011). ASTYM® categorizes outcomes into six different criteria: pain reduction, functional status, pain and functional improvement, patient satisfaction, and patient goals. For minor traumas, such as a sprain or a strain, ASTYM® led to a 93.4% functional improvement after eight treatments, while injuries like a repetitive stress improved 91.9% after nine treatments (Performance Dynamics, Muncie, IN, USA, 2014). For a hamstring strain, eight treatments were performed, leading to a 97.2% increase in functional activity (Performance Dynamics, Muncie, IN, USA, 2014). The current study showed significant range of motion increases in two treatments, regardless of the addition of superficial heat; this shows a promising trend that would likely increase other clinical factors, like functional status. This study also quantified perceived patient comfort; participants who rated the ThermoStim treatment as "very uncomfortable" stated the treatment felt like being tickled. Despite this, 100% of the participants stated they would request IASTM as a treatment option in the future, due to feeling more flexible post-treatment. This could lead to a perception of pain reduction in participants in future studies that quantified that factor.

While the participants in the current study had tight hamstrings, but were otherwise healthy, practitioners who perform gua sha target musculoskeletal pain by applying massage strokes in a repetitive, unidirectional manner for five to seven minutes or until petechiae forms. The current study used a treatment time of ten minutes and though petechiae was noted for four participants, it did not end the treatment session. Gua sha is thought to decrease pain by increasing superficial perfusion, supported by Sandberg, et al. (2003). Sandberg et al. (2003) reported a 400% increase in superficial perfusion at 7.5 minutes post-treatment and at 25 minutes post-treatment. In Nielson's (2009) pilot study, gua sha was performed on participants' back muscles and superficial tissue perfusion was recorded using laser Doppler imaging. The reduction in back pain and inflammation for the participants was attributed to the increase in microcirculation from the gua sha treatment. In addition, Loghmani & Warden (2013) performed IASTM bilaterally on participants and while there was no immediate change in perfusion, there was a significant increase on the limb treated with IASTM after the 4th and 9th treatments which lasted up to one week post-intervention. While the current study did not record tissue perfusion, the participants in the current study also had a significant increase in range of motion and all stated they would request IASTM treatment as a future treatment option.

The use of superficial heat in the current study can be attributed to Knight, et al. (2001) who found that superficial heating combined with stretching showed statistically significant improvements in hip range of motion. In theory, using a superficial heat setting of five and performing IASTM with the ThermoStim in the current study may have shown range of motion increases that were significantly greater than the use of IASTM alone. However, the addition of superficial heat had no increased effect on range of motion. In contrast Knight, et al. (2001) and Starkey (2004) reported that application of a moist hot pack can increase hamstring range of motion more than stretching and advises that moist hot packs need to be combined with other modalities, such as IASTM, in order to increase tissue elongation. The current study used dry heat through the ThermoStim probe, which may have been a factor as to why there wasn't an additional increase in range of motion.

Regardless of the addition of superficial heat, range of motion increases were significant for all participants, with gender having no effect on the results of the current study. Hanson & Day (2012) found that gender did have an effect on the results of their study. The researchers reported that the 20 females in their study had greater baseline range of motion than the 24 males in their study prior to a thermotherapy intervention, but showed the greatest increases in range of motion post-intervention, which were statistically significant. In the current study, gender had no impact on baseline or post-treatment results. In the Hanson & Day (2012) study, participants received superficial heat through a stationary moist hot pack, warm whirlpool, or active exercise, while the current study used a moving, dry heat. The three modalities used in the Hanson & Day (2012) study would be more likely to increase tissue temperature to the range of 104-112°F range needed to increase tissue extensibility. The ThermoStim reports that the heat setting of five correlates to 112°F, however, when the probe is moving along large target tissues, the tissues may not reach that temperature.

One theory about how superficial heat creates greater range of motion was explored by Lin (2003). The researcher reported that moist hot packs increased range of motion by raising local tissue temperature which reduced the friction between tissues, such as a tendon sheath or between muscle and fascia. The participants in the current study that felt a warming or heating response may very well have felt an increase in temperature due to the friction of the IASTM treatment, or may have had increased range of motion due to the decreased resistance between tissues. Lin (2003) also reported that superficial heating caused a decrease in musculoskeletal pain.

Knight, et al. (2001) also reported increases in range of motion from the use of moist hot packs, when compared to a control group. Participants who used moist hot packs increased their range of motion by an average of 4.38°, while the average passive range of motion increased by 4.90°. In the current study, all participants had significant increases in range of motion, but there was no difference between groups, meaning the increased range of motion should be due to the IASTM treatment, and not the superficial heat setting. This may be due to the fact that the superficial heat setting on the ThermoStim is a dry heat, not a moist heat like a moist hot pack. This also may be due to the movement of the probe head across the target tissue, meaning the surface temperature of the probe is approximately 112°F, but that warmth is not penetrating the tissues enough to increase extensibility. However, the increased tissue temperature, which may be attributed to the friction from the treatment, still created greater perceived patient comfort, though there were no differences between groups. While Knight, et al. (2001) was concerned with range of motion increases related to the use of moist hot packs, a study performed by Khamwong, et al. (2011) examined the effects of prophylactic superficial heat on the damage caused in wrist extensors by eccentric exercise. The control group received no superficial heat prior to performing 300 maximum repetitions of eccentric exercise designed to tax the wrist extensors. The experimental group received 20 minutes of prophylactic superficial heat prior to performing the same eccentric exercise. The researchers noted that superficial and deep heating were effective in reducing the symptoms of muscle damage by increasing the skin temperature 40-45° Celsius and the underlying muscle temperature 1-3° Celsius. While the current study did not measure skin or intramuscular temperature and treatment lasted 10 minutes, overall perceived patient comfort was rated at moderately comfortable with the heating or warming response being rated as slightly to moderately warm.

In the only study performed utilizing the ThermoStim (Guffey, et al., 2013), both groups were treated for plantar fasciitis and both improved in function and decreased in pain, but the experimental group had statistically significant decrease in pain and improvement in function. These results are confounding due to the addition of laser therapy and a stretching protocol, neither of which were used in the current study.

A possible reason for the increase in hamstring range of motion could be due to the relaxation of the muscle post-treatment. The IASTM treatment protocol used in this study was based on Graston Technique® protocol, which has roots in massage and cross-friction massage. Another possible reason for the increased range of motion could be due to the decrease in adhesions or scar tissue within the hamstrings muscle group, due to IASTM treatment. While many participants did not report experiencing a warming or heating response due to the ThermoStim treatment, friction from the instrument could have played a minor role in producing a sub-sensory heating response to increase the range of motion.

The ThermoStim showed significant increases in range of motion for all participants in this study; all participants were intercollegiate student-athletes. According to these results, IASTM treatments would be beneficial to an athlete, regardless of gender, sport, or the inclusion of superficial heat. The data supports the hypothesis that IASTM is an appropriate option for increasing range of motion on healthy tissue when the participant has tight hamstrings, as defined in this study.

Recommendations for Clinical Utilization

The ThermoStim showed significant results for increasing the range of motion of the hamstrings in healthy participants by utilizing the IASTM aspect of the probe. Every participant was, however, an NCAA Division III intercollegiate athlete who, whether in-season or out-of-season, continued to perform strength and conditioning exercises or participated in practices. Many of the participants had crepitus within their hamstrings muscles or tendons, showing likely damage in the past. This study supports performing IASTM with the ThermoStim on unhealthy, sub-acute to chronic hamstring strains, which would likely decrease the presence of adhesions within the target tissues, leading to greater range of motion and perceived patient comfort.

The inclusion of superficial heat during IASTM treatment had no impact on perceived patient comfort during this study. Most participants felt a slightly warming or heating response, but the effect had no impact on the range of motion of the participants. This slight increase could be attributed to friction from the treatment, rather than the superficial heat setting itself. Until further data supports that the ThermoStim can raise tissue temperatures to those needed for tissue extensibility, the inclusion of superficial heat during IASTM may be useful for the beginning stages of treatment so the instrument isn't cool to the touch.

Limitations of Study

This study was limited to the effects of IASTM and superficial heat on healthy participants within an NCAA Division III intercollegiate student-athlete population with tight hamstrings. A standardized treatment protocol was used for all participants, meaning injured areas were not addressed for each participant. By treating individual's adhesions or scar tissue specifically, the researcher could have potentially measured greater range of motion gains, while the participant may have perceived greater patient comfort post-treatment. Furthermore, participants' range of motion was measured by passively extending the knee while the hip was flexed to 90 degrees. Participants' range of motion must have measured less than 70 degrees in order to be included in the study. Those participants who had less range of motion prior to the study (40° of passive knee extension) trended towards greater increases while participants who had greater range of motion (70° of passive knee extension) had lesser range of motion increases. In addition, utilizing moist hot packs, rather than dry superficial heat like the current study did, may have led to a difference in range of motion between groups.

Recommendations for Future Research

This study was limited to the effects of IASTM and superficial heat on healthy participants within an NCAA Division III intercollegiate student-athlete population with tight hamstrings. Further studies are needed to determine if IASTM through the ThermoStim could improve hamstring range of motion on injured tissue. Since IASTM is used to decrease adhesions in the muscle, future research should employ diagnostic ultrasound to measure the amount and size of adhesions or scar tissue in the muscle prior to and after intervention. Although there was no significant difference between groups, the use of thermocouples to measure skin surface and intramuscular temperature would be beneficial to determine whether superficial heat applied by the ThermoStim could raise the temperature of the skin and underlying tissues to 104-113°F in order to increase range of motion further. In the future, this researcher will be creating individualized treatment plans for each athlete, while utilizing and quantifying range of motion increases obtained during IASTM treatments. There were only two treatment sessions in the current study, whereas other IASTM programs advise two treatment sessions per week over four to eight weeks.

Conclusion

While the ThermoStim probe is new and has little published literature, the technique of scraping the skin with an instrument to create greater range of motion dates back hundreds of years from all corners of the globe. Dynatronics has now packaged some of the most utilized modalities into one handheld probe, the ThermoStim, that leaves the practitioner in charge of making a clinical decision about treating an athlete's condition. What this study showed is that the ThermoStim can combine multiple modalities into one treatment time, which will decrease the overall time needed for each athlete to receive treatment. However, this study also showed that practitioners can create just as great, if not greater, range of motion through the use of IASTM alone, which also decreases our overall treatment time per athlete. Healthcare practitioners are now free to choose which modalities to utilize for each individual athlete very quickly and easily with the ThermoStim probe and the SolarisPlus unit, while knowing they are creating significant range of motion increases, and presumably, decreasing overall injury rates.

REFERENCES

American Massage Therapy Association (2009). Retrieved from https://www.amtamassage.org/index.html

Black, D.W. (2010). Treatment of knee arthrofibrosis and quadriceps insufficiency after patellar tendon repair: A case report including use of the Graston Technique®. *International Journal of Therapeutic Massage and Bodywork, 3*(2), 14-21.

Braun, M., Schwickert, M., Nielson, A., Brunnhuber, S., Dobos, G., Mulal, F., Ludtke, R., & Michalsen, A. (2011). Effectiveness of traditional Chinese "gua sha" therapy in patients with chronic neck pain: A randomized controlled trial. *Pain Medicine, 12*, 362-369.

Carey-Loghmani, M.T., Schrader, J.W., & Hammer, W.I. (2015). Clinical foundations for Graston Technique®.

Chamberlain, G.J. (1982). Cyriax's friction massage: A review. *The Journal of Orthopaedic and Sports Physical Therapy, 4*(1), 16-22.

Davidson, C.J., Ganion, L.R., Gehlsen, G.M., Verhoestra, B., Roepke, J.E. & Sevier, T.L. (1997). Rat tendon morphologic and functional changes resulting from soft tissue mobilization. *Medicine & Science in Sports & Exercise, 29*(3), 313-319.

Dynatronics. (2012). Dynatron SolarisPlus Unit. [Brochure]. Salt Lake City, UT.

Fan, K.W. (2006). Foot Massage in Chinese Medical History. *The Journal of Alternative and Complementary Medicine, 12*(1), 1-3.

Gehlsen, G.M., Ganion, L.R., & Helfst, R. (1999). Fibroblast responses to variation in soft tissue mobilization pressure. *Medicine & Science in Sports & Exercise, 31*(4), 531-535.

Guffey, J.S., Head, P., Bowman, A., & Kaloghirou, A. (2013). Effects of light on pain and function in patients with plantar fasciitis: A pilot study. Unpublished manuscript, Department of Physical Therapy, Arkansas State University, Jonesboro, Arkansas.

Hammer, W.I. (2008). The effect of mechanical load on degenerated soft tissue. *Journal of Bodywork and Movement Therapies, 12*, 246-256.

Hanson, M. & Day, J. (2012). Effects of different heating modalities on hip flexion passive range of motion. *International Journal of Athletic Therapy and Training, 17*(6), 27-30.

Hemmings, B.J. (2001). Physiological, psychological and performance effects of massage therapy in sport: A review of the literature. *Physical Therapy in Sport, 2*, 165-170.

Howitt, S., Jung, S., & Hammonds, N. (2009). Conservative treatment of a tibialis posterior strain in a novice triathlete: A case report. *Journal of the Canadian Chiropractic Association, 53*(1), 23-31.

Howitt, S., Wong, J., & Zabukovec, S. (2006). The conservative treatment of trigger thumb using Graston Techniques® and Active Release Techniques®. *Journal of the Canadian Chiropractic Association, 50*(4), 249-254.

Hyde, T.E. & Gengenbach, M.S. (2007). *Conservative management of sports injuries* (2nd ed.). Sudbury, MA: Jones and Bartlett Publishers.

Khamwong, P., Nosaka, K., Pirunsan, U., & Paungmali, A. (2011). Prophylactic effect of hot pack on symptoms of eccentric exercise-induced muscle damage of the wrist extensors. *European Journal of Sport Science, 12*(5), 443-453.

Knight, C.A., Rutledge, C.R., Cox, M.E., Acosta, M., & Hall, S.J. (2001). Effect of superficial heat, deep heat, and active exercise warm-up on the extensibility of the plantar flexors. *Physical Therapy, 81*(6), 1206-1214.

Lin, Y.H. (2003). Effects of thermal therapy in improving the passive range of knee motion: Comparison of cold and superficial heat applications. *Clinical Rehabilitation, 17,* 618-623.

Loghmani, M.T. & Warden, S.J. (2009). Instrument-assisted cross-fiber massage accelerates knee ligament healing. *The Journal of Orthopaedic and Sports Physical Therapy, 39*(7), 506-514.

Loghmani, M.T. & Warden, S.J. (2013). Instrument-assisted cross fiber massage increases tissue perfusion and alters microvascular morphology in the vicinity of healing knee ligaments. *BMC Complementary and Alternative Medicine, 13*, 240-249.

McCormack, J.R. (2012). The management of bilateral high hamstring tendinopathy with ASTYM® treatment and eccentric exercise: A case report. *Journal of Manual and Manipulative Therapy, 20*(3), 142-146.

McCormack, J.R. (2012). The management of mid-portion Achilles tendinopathy with ASTYM® and eccentric exercise: A case report. *The International Journal of Sports Physical Therapy, 7*(6), 672-677.

Miners, A.L. & Bougie, T.L. (2011). Chronic Achilles tendinopathy: A case study of treatment incorporating active and passive tissue warm-up, Graston Technique®, ART®, eccentric exercise, and cryotherapy. *Journal of the Canadian Chiropractic Association, 55*(4), 269-279.

Moraska, A. (2005). Sports massage: A comprehensive review. *Journal of Sports Medicine and Physical Fitness, 45*, 370-380.

Nejo, Y., Gange, K., German Knodel, N., & Blodgett Salafia, E. (2014). The Graston Technique® increases hamstring flexibility. (Unpublished master's thesis). North Dakota State University, Fargo.

Nielson, A. (2009). Gua sha research and the language of integrative medicine. *The Journal of Bodywork and Movement Therapies, 13*(1), 63-72.

Papa, J.A. (2012). Two cases of work-related lateral epicondylopathy treated with Graston Technique® and conservative rehabilitation. *Journal of the Canadian Chiropractic Association, 56*(3), 192-200.

Performance Dynamics, Inc., Muncie, IN, USA, 2014 (ASTYM®)

PR, N. (2014, February 14). Dynatronics announces second quarter financial results and introduction of new thermostim probe. PR Newswire US.

Sandberg, M., Lundeberg, T., Lindberg, L-G., & Gerdle, B. (2003). Effects of acupuncture on skin and muscle blood flow in healthy subjects. *The European Journal of Applied Physiology, 90*, 114-119.

Sevier, T. (2016, January 6). Phone interview with H. Bates.

Slaven, E.J. & Mathers, J. (2011). Management of chronic ankle pain using joint mobilization and ASTYM® treatment: A case report. *Journal of Manual and Manipulative Therapy, 19*(2), 108-112.

Smith, J.M., Sullivan, S.J., & Baxter, G.D. (2010). Massage therapy: more than a modality. *New Zealand Journal of Physiotherapy, 38*(2), 44-51.

Starkey, C. (2004). *Therapeutic Modalities* (3rd ed.). Philadelphia, PA: FA Jones Company.

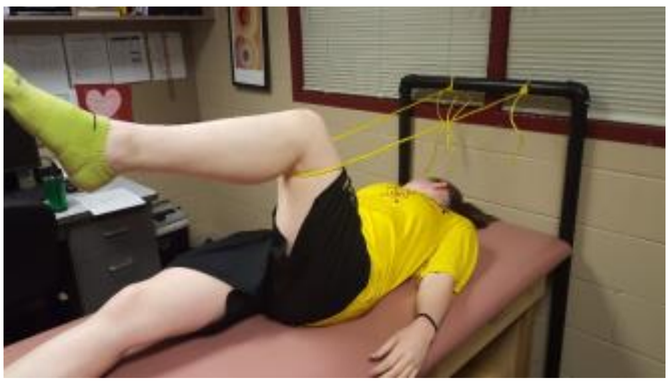
Weinberg, R., Jackson, A., & Kolodny, K. (1988). The relationship of massage and exercise to mood enhancement. *The Sport Psychologist, 2*, 202-211.

Yildirim, N., Ulusoy, M.F., & Bodur, H. (2010). The effect of heat application on pain, stiffness, physical function and quality of life in patients with knee osteoarthritis. *Journal of Clinical Nursing, 19,* 1113-1120.

APPENDIX A. INSTRUMENTS

Graston Technique® Instruments

ThermoStim, Dynatronics, Salt Lake City, UT



Homemade stand to measure knee extension passive range of motion

APPENDIX B. PARTICIPANT SURVEY

1) How familiar are you with instrument assisted soft tissue mobilization (IASTM)?
    a. I've never heard of it
    b. I've heard of it, but never have had it performed on me
    c. I've had IASTM performed on me before and felt it was beneficial
        i. Which treatment? (i.e. Graston Technique®, ASTYM®, etc.)
    d. I've had IASTM performed on before and did not feel it was beneficial
        i. Which treatment? (i.e. Graston Technique®, ASTYM®, etc.)
2) How would you describe the instrument assisted soft tissue mobilization treatment today?
    a. Very uncomfortable
    b. Slightly uncomfortable
    c. Neutral
    d. Slightly relaxing
    e. Very relaxing
3) Did you experience a warming/heating response with your treatment today?
    a. Yes
    b. No (skip to question 6)
4) If you responded 'Yes' to question 3, how warm/hot did you feel?
    a. Very warm
    b. Moderately warm
    c. Slightly warm
    d. Slightly cool
    e. No warmth or cooling effect felt
5) If you responded 'Yes' to question 3, how would you describe the warming/heating response?
    a. Very uncomfortable
    b. Slightly uncomfortable
    c. Neutral
    d. Slightly relaxing
    e. Very relaxing
6) Would you request instrument assisted soft tissue mobilization as a treatment again?
    a. Yes
        i. Why?
    b. No
        i. If not, why?
7) Anything else you'd like to share with the researchers?