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Graston Technique Pressure Changes on Hamstring Range of Motion

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Context: Instrument assisted soft tissue mobilization (IASTM) can be applied as a myofascial treatment using a set of instruments and is growing in popularity with clinicians. There is a gap in the literature identifying the best pressure application recommendation without eliciting unnecessary discomfort.

Objective: To investigate if using light or firm pressure applied with the Graston Technique (GT) would have an impact on changing range of motion (ROM).

Design: Single blinded randomized control trial

Setting: Laboratory

Patients or Other Participants: Twenty-seven physically active participants (14 females and 13 males; age: 23±3.4 years; height: 68.59±3.32; weight: 83.6±30.79) were recruited and assessed for hamstring tightness. Participants were enrolled if they had 70° or less of a passive straight leg raise (PSLR) as measured at first resistance (R1). Qualifying participants were randomly allocated into three groups: firm pressure (FP), light pressure (LP), or control.

Interventions: The GT protocol was implemented for this study. Participants began treatment with a ten-minute bike warm up and were divided into groups. The two pressure groups were treated on the hamstring muscle of the participants' dominant leg with the same treatment protocol while the control group only received stretching education and sat in the treatment room for seven minutes. GT1 and GT5 were used for one minute each to warm up the tissue and

identify adhesions. The hamstring was divided into four sections and treated 30 second each with GT4. This was measured and applied using the pressure allocation. This was followed by GT5 and GT1 for one minute each. Firm pressure was maintained at 6.44 N±2.38 and light pressure at 1.68 N±0.83. After treatment, the participant completed three hamstring exercises and a static stretch of passive hip flexion with knee extended taken to the participants' end range. Participants finished with a final measurement of PSLR to R1. Twenty-four hours later, the participant returned and was measured using a PSLR.

Main Outcome Measures: Hamstring ROM measurements taken at baseline, at the completion of the treatment session and 24-hours later using a PSLR. Subjects scored their perceived discomfort at baseline and at the 24 hour follow up using a visual analog scale (VAS).

Results: ROM was analyzed with a mixed between-within subjects ANOVA which showed that ROM had no statistically significant changes across time (p=.332) and there was no significance between pressure groups and the control group (p= .472). The VAS scale was analyzed using a Kruskal Wallis test which showed no significance between groups ($\chi^2(2) = 3.61$, $p = 0.17$).

Conclusion: GT does not increase hamstring ROM regardless of pressure. Clinicians can use their own clinical judgement when deciding when and how to apply GT or another form of IASTM to patients based on the patient's history, pathology, etc.

KEYWORDS: Graston technique, IASTM, hamstring, range of motion, pressure, passive straight leg raise

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CHAPTER I: INTRODUCTION

Manual therapy is a treatment intervention that can encompasses a number of different treatment techniques aimed at manipulating soft tissue.[1] One of those techniques is myofascial release, which is used to help lengthen the muscle and the fascia in order to increase mobility and decrease the amount of adhesions in muscle.[2-5] This can be accomplished with either instruments or the clinician's hands to achieve a treatment goal.[2] Instrument assisted soft tissue mobilization (IASTM) is a specific type of manual therapy that uses various instruments to treat pain, functional limitations, and dysfunctional impairments.[1,4,6,7] As IASTM is becoming more popular in many clinical settings, there is also a great deal of variability with treatment application.[4,8] This is a result of a lack of specific educational materials as well as clinician preference while applying treatment. Graston Technique® (GT) is the only IASTM treatment that provides an educational component.

GT uses a set of six stainless steel instruments to assist in breaking down scar tissue, tissue adhesions, and manipulating tissue.[1] Application of the instruments depends on the treatment goal and the patient's current phase of healing.[4] Treatment goals can range from increasing range of motion (ROM), decreasing pain, and decreasing the amount of soft tissue adhesions.[6,8] GT is theorized to manipulate adhesions by separating fibers and restarting the inflammatory process.[3-5] The instruments amplify the feel of the tissue underneath the instruments, allowing the clinician to detect unevenness in the muscle tissue, or the adhesions, as they pass through the area, and allow a more specialized treatment.[8,9]

The shapes and edges of the GT instruments assist in fitting the shapes of the body in order to scan, locate, and treat myofascial trigger points and adhesions in the soft tissue.[1] This specialized treatment assists in relaxing the tissue and separating the fibers in order to help

relieve pain and restore the movement restriction.[1] Several theories exist to help further explain the outcomes from a GT application.[10-12] One theory behind GT is the treatment causes a small amount of trauma to the affected area, resulting in inflammation to occur.[1] This in turn increases blood flow to the area, thus promoting the healing process to begin in the affected tissues.[1] The second theory is when applying a manual therapy technique, you initiate the restoration of muscle function by realigning the muscle fibers.[13] A third theory focuses on the neurophysiological response to the treatment. Muscles and myofascial tissue have the largest number of sensory nerves within the tissue.[11] These sensory nerves are believed to cause relaxation of the smooth or striated muscle fibers by sending information from the stimulus to the muscle tissue causing them to relax, which may affect the ground substance within the area.[10,12] The mechanical deformation, along with the sensory input to the peripheral nervous system, is believed to have the ability to immediately affect muscle tone.[12]

Aside from the instruments themselves, GT is different from other forms of IASTM techniques in that it has a specialized protocol which dictates the application of treatment to the patient as well as educational components for their clinicians.[6] The full GT protocol includes a soft tissue warm up with cardio or modalities, followed by GT instrument application, high rep/low load exercises, stretching ,and finishes with optional cryotherapy.[6] Exercises and stretches are performed after treatment to help assist the fibers of the treated area to properly realign and heal with proper function.[6] Specifically, GT has a set protocol which allows it to be called GT. When using the instruments without application of the full GT, it becomes IASTM.

While there is a great amount of evidence that surrounds GT in various aspects, there is minimal evidence that changing the amount of pressure applied by the clinician and the instruments used make a difference in treatment in regards to ROM.[5] Previous research has

shown physiological differences with varying amounts of pressure. Gehlsen et al.[5] showed that varying amounts of pressure did cause a change in fibroblastic activity within the Achilles tendon of a rat population over the course of four IASTM treatments, but ROM was not assessed. They concluded that extreme pressure provided the largest amount of change in the tissue.[5] They quantified extreme pressure as 1.5 N/mm^{-2} while applying treatment to a rat's Achilles tendon.[5] With this study showing differences in the treatment, it is necessary to evaluate changes in pressure in regards to human ROM, so clinicians can use the most efficient treatment and produce positive outcomes. In general, GT recommends starting treatment with light pressure and shallow depth as they are introduced to it, and then progress to a more aggressive treatment with more pressure as their tissue adapts in consecutive sessions.[6] Some common treatment reactions are the patient reporting feeling uncomfortable from the instruments, bruising or petechia, as well as tissue release.[6] Patients might have a poor experience with GT as it is not a comfortable treatment. Knowing how much pressure to apply to achieve an increase in ROM would assist in eliminating unnecessary discomfort for the patient, therefore resulting in a better treatment overall.

One area of the body that has consistently been shown to lack ROM and potentially results in injury is the hamstring muscle group.[14-16] The hamstring muscles are a key group of muscles in all sprinting sports, and are commonly injured among athletes.[14,17] Bradley et al.[15] suggested that more ROM interventions are necessary to try and limit the amount of hamstring strains. This is necessary for those individuals that have decreased hamstring ROM due to the chance of static stretching decreasing power capacity in the muscle.[15] This evidence suggests that normal ROM is key to decreasing the chance of injury, not just in the hamstring but throughout the body.[15,18] There is evidence that a lack of ROM is the cause of many hamstring injuries.[14-16]

One way we can treat this lack of ROM is through a myofascial release, IASTM, or GT, if the source is coming from adhesions within the muscle.[19] These adhesions can be a product of microtrauma that will cause tightness within the muscle tissue, resulting in dysfunction.[18] This tightening of the tissue is the body attempting to protect itself.[18] As the tissue is restricted, it loses its pliable nature, therefore becoming tight.[18] This tightness can lead to dysfunction around the body as it adapts to the change.[18] Using the knowledge of where the tightness is occurring will help determine where dysfunction may occur due to fascial lines and where the line of pull occurs from these lines.[10]

As the hamstring is a common muscle to injure in athletics due to a decrease in its ROM, it is key to identify the best pressure to apply using GT in order to combat this. GT advises using light pressure and to build upon that,[6] but it is necessary to know if it is better to continue treating with light pressure, or if a firm pressure yields a better outcome. Therefore, the primary purpose of this study was to assess the effects of different pressures while applying GT on hamstring ROM, as represented by a passive straight leg raise (PSLR).

It was hypothesized that there would be an increase in hamstring ROM and have a higher VAS score after receiving GT with firm pressure, compared to the group with light pressure or the control group.

CHAPTER II: LITERATURE REVIEW

SKELETAL ANATOMY

The basic functions of bone and the skeletal system is to provide support, protection, aid in movement, balance electrolytes, aid in acid-base balance, and to form blood cells.[20] Bone is called osseous tissue and calcium phosphate deposits, as well as other minerals, provide the hardened matrix of bone.[20] Long bones help provide major movements in the body by being an attachment site for muscle.[20] Some examples would be the humerus, tibia, and fibula. The long bone is surrounded by a hard shell which is called compact bone.[20] This encases a section of the long bone that houses bone marrow.[20] At both ends of the long bone are sections that contain more spongy bone.[20] Spongy bone is composed of an intricate lattice type matrix laid out in a way to assist in the strength of a bone, while still allowing for light weight bones.[20] It is encompassed by endosteum and the spaces of this lattice matrix is filled by bone marrow.[20] Articular cartilage is located at the ends of these bones, where they meet other bones and create a joint.[20] The articular cartilage, along with synovial fluid, creates a smooth surface for the bones to move.[20] Flat bones are bones that are flat and shaped like plates.[20] Some flat bones, such as the cranial bones, are held together by sutures to other flat bones.[20] They have two layers of compact bone, with a layer of spongy bone in the middle.[20] This spongy bone is called diploe.[20] Sesamoid bones are bones that grow within tendons.[20] This growth occurs as a result of strain on the tissue.[20]

The pelvic girdle is made up of the two hip bones and the sacrum.[20] The hip bones are made up of the ilium, ischium, and the pubis.[20] The ilium extends from the iliac crest to the acetabulum.[20] The ischium makes up the inferoposterior portion of the hip.[20] The pubis, or the pubic bone, is the most anterior bone of the pelvic girdle, and can be palpated just above the

genitalia.[20] The pelvic girdle is meant for protection of the bladder, reproductive organs, and attachment sites for muscles and ligaments.[20] The two hip bones articulate with each other in the anterior portion of the hip and are connected by the pubic symphysis.[20] They then connect to vertebrae and the sacrum on the posterior side.[20]

The long bone that is associated with the hip is the femur.[20] The pelvic girdle connects with the femur with the head of the femur sitting in the acetabulum, creating a ball and socket joint.[20]

The long bones associated with the knee are the fibula and the tibia.[20] The femur is considered the strongest bone in the body, holding most of the body's weight, and has many bony landmarks where different muscles attach.[1,20] The tibia is thick and is the weight bearing bone of the lower leg, or crural region.[20] The top is made of flat articular surfaces where the medial and lateral condyles of the femur sit.[20] The tibial tuberosity is a bony prominence where the quadriceps muscles attach.[20] The tibia ends just above the ankle, and forms the medial malleolus.[20] The fibula does not hold any body weight, and helps to stabilize the ankle.[20] It is thicker at the head of the fibula, and ends at the ankle joint, or the tarsal region, to form the lateral malleolus.[20] The tibia and the fibula are connected by a membrane called the interosseous membrane as well as ligaments at the proximal and distal ends of the tibia.[20] The sesamoid bone associated with the knee is the patella.[20] This is also commonly known as the knee cap.[20] This is located in the quadriceps tendon, between the femur and the tibia.[20] It helps to connect the femoral and crural regions.[20] It is usually wider at the superior portion, and narrows to a point, to form a triangle.[20] It moves inside the intercondylar notch of the femur.[20]

MUSCLE ANATOMY

The muscle fiber, or a myofiber, has several components that make it a functional tissue.[20] The most basic unit of the muscle, which is the contractile portion of the muscle fiber is

the sarcomere.[20] These sarcomeres contract and bring together the Z-discs of the muscle fiber.[20] These segments are measured from z-disc to z-disc. The sarcolemma is the membrane that surrounds the muscle fiber and the cytoplasm of the muscle fiber is the sarcoplasm.[20] The sarcoplasm mostly contains myofibrils, which are long protein cords of microfilaments.[20] It also contains glycogen which are carbohydrates that provide energy during high levels of exercise.[20] Myoglobin stores oxygen for the muscle fiber until it is needed during exercise.[20]

The muscle fiber contains several nuclei which is a result from development while a fetus is in utero.[20] These stem cells are called myoblasts, and sometimes the body has additional unspecialized stem cells which can be used when the muscle is injured to help develop more myofibers.[20] This is uncommon, however, and most muscle repair occurs by fibrosis rather than regeneration.[20]

There are other organelles that are housed in the sarcoplasm, between the myofibrils.[20] The sarcoplasmic reticulum makes a network around the myofibrils, and it holds calcium ions which are key for muscle activation.[20] Dilated end sacs are called terminal cisternae, and these cross the muscle fiber from one side to another.[20] These are key because they are closely associated with T-tubules, which also span the muscle fiber, and they together form a triad.[20] The T-tubules act as signals for the sarcoplasmic reticulum to know when to release the calcium.[20]

Myofibrils are bundles of protein microfilaments that run parallel to each other.[20] These are called myofilaments and are comprised of three types. The first is a thick filament.[20] They are composed of several hundred molecules of myosin.[20] They are two chained molecules intertwined.[20] They have a club like shape at the end of the filament.[20] These filaments are formed so that each end is angled to the right or left, and they have a small space that is called the bare zone that does not have any heads in either direction.[20] The second component is the

thin filament.[20] These are two intertwined protein strands called fibrous actin, and the individual subunits of protein are the globular actin.[20] This globular actin has a site where they can bind to the myosin molecules.[20] While a person is relaxed, the tropomyosin is released to block these active sites to keep myosin from connecting to the globular actin.[20] Tropomyosin also has troponin, which is a calcium binding protein to assist in this function.[20] The final filament is the elastic filament.[20] This is made of a protein called titin, which lines each thick filament so that is may attach to the Z-discs at one end, and the M-line at the other side.[20] This has multiple functions such as, allows for the thick filaments to be stabilized, it centers the filaments in the middle of the thin filaments, prevents overstretching, and helps the elastic muscle recoil when it relaxes.[20]

The myosin and the actin are considered the contractile proteins as they are the portions that contract the muscle.[20] The proteins that regulate this contraction are called tropomyosin and troponin.[20] They determine when the muscle fiber should contract or not.[20] A second key protein is dystrophin, which links actin filaments to proteins on the edge that are in the inner surface of the sarcolemma.[20]

Striations occur in skeletal muscle and cardiac muscle and are formed from the aligned actin and myosin.[20] There are two types, one lighter alternating with one darker section.[20] The darker portions are made of the A bands, which stands for anisotropic, and consists of thick filaments aligned together.[20] There is a section of the A band where the thin filaments do not reach the area, and this area is called the H band.[20] In this band, the thick filaments are connected by a transverse protein called the M line.[20] The lighter portion is the I band, which stands for isotropic, and is bisected by a dark z-disc, or z-line.[20] This line provides a place of connection between the thin and elastic filaments.[20]

Skeletal muscle needs to be stimulated by a nerve to stimulate a contraction.[20] Somatic motor neurons serve the skeletal muscle, and their axons, called somatic nerve fibers, lead to the skeletal muscles.[20] Each muscle fiber is supplied by one of these motor neurons.[20] One nerve fiber and all the fibers it innervates are called motor units because muscle fibers contract in unison and act as one unit.[20] These contractions start as weak contractions and move across the whole muscle.[20] There are two different sized motor units.[20] There are small motor units that control 3-6 muscles fibers and control fine motor skills such as eye movement, and there are large motor units that control body movement.[20] This selective nature helps to prevent muscle fatigue.[20]

The synapse is the location where the nerve fiber meets its target cell.[20] A motor fiber synapse is called a neuromuscular junction.[20] At the end of each synapse, there is a synaptic knob where the nerve fiber ends on the muscle fiber.[20] This connection is separated from the muscle fiber by the synaptic cleft.[20]

The hamstring muscle is comprised of three muscles, the semimembranosus, the semitendinosus, and the biceps femoris.[1,20] The semitendinosus originates at the ischial tuberosity, inserts on the upper anterior medial surface of the tibia just below the condyle.[21] Its actions are flexion of the knee, extension of the hip, posterior pelvic rotation, internal rotation of the hip, and internal rotation of the flexed knee.[21] It moves in the sagittal and the transverse planes.[21] Innervation comes from the sciatic nerve along the tibial division (L5, S1, and S2).[21] The semimembranosus originates on the ischial tuberosity and inserts on the posteromedial surface of the medial tibial condyle.[21] Its actions are flexion of the knee, extension of the hip, posterior pelvic rotation, internal rotation of the hip, and internal rotation of the knee.[21] It moves along the sagittal and transverse planes.[21] It is innervated by the sciatic nerve along the tibial

division (L5, S1, and S2).[21] The biceps femoris is comprised of two parts, the long head and the short head.[21] The long head inserts on the ischial tuberosity and inserts on the head of the fibula and lateral condyle of the tibia.[21] The short head originates on the lower half of the linea aspera, and lateral condyloid ridge.[21] It also inserts on the head of the fibula and lateral condyle of the tibia.[21] Both heads perform flexion of the knee, extension of the hip, posterior pelvic rotation, external rotation of the hip, and external rotation of the knee.[21] Both heads perform in the transverse and sagittal planes.[21] The long head is innervated by the sciatic nerve along the tibial division (S-S3).[21] The short head is innervated by the sciatic nerve along the peroneal division (L5, S1, and S2).[21]

FASCIAL ANATOMY

Fascia is a body wide complex that goes from head to toe.[10] It is related to the extracellular matrix (ECM) which distributes movement and gravity stresses, while at the same time maintaining the shape of the body. With its chemical makeup, it provides the environment necessary for the cells imbedded in it. This forms a framework for them to stay in place while maintaining the proper consistency for nutrients to diffuse across the tissue.[22] The ECM is a living matrix which reaches every part of the body.[10] It is a "nuclear matrix within a cellular matrix within a connective tissue matrix."[10] The ECM is a connective tissue fabric and forms the body wide complex known as fascia, or fascial net.[10] Connective tissue is unique in that it helps to connect all the cells in the body to its neighboring cell.[10] It also helps to connect the inner cell components in order to have a mechanical state in its body.[10] It is thought that as a part of its connective nature, it is able to adapt and respond to changes in pressure, touch, and take this information across the body.[10] "The most general statement that can be made about any of these Anatomy Trains lines is that strain, tension (good or bad), trauma, and movement tend to be

passed through the structure along these fascial lines of transmission."[10] Anatomy trains is a descriptive word to talk about the 12 myofascial meridians in the human body.[10]

Within the connective tissue system, the fibroblasts along with a second similar component that makes up most of the fibers help to make it a strong unit.[10] The most important fibers of connective tissue are collagen, elastin, and reticulum.[10] Reticulum is predominantly present in an embryo, but is quickly replaced by collagen.[10] Elastin is present in the ear, nose, or some ligaments.[10] Elastin is present in areas where some flexibility and elastic components are necessary.[10] Collagen is the most abundant fiber in the body, and is the primary component in fascia.[10] Some examples of collagen include heart valves, lungs, and meninges.[10]

The material that holds water and other components together in cells to allow distribution of metabolites is called ground substance.[10] It is very resistant to bacteria growth, therefore it can be found in the immune system barrier to stop bacteria spread.[10] Ground substance is unique in that it can help glue the trillions of cells in the body together, and yet allows for free exchange life sustaining substances.[10] It allows for a variety of conditions, becoming more or less malleable for the situation.[10] An example of ground substance is synovial fluid in joints.[10] Some areas hold a larger quantity, such as joints, or smaller quantities such as the aqueous humor in the eye.[10]

The fibrous net, or otherwise known as fascia, is considered a whole body communicating network.[10] Meaning, if one were to remove everything that was not considered part of the fibrous system, then one could still see the general shape of a human body.[10] Fibrous tissue holds most of the body together, such as the meninges in the brain, muscle sheaths, and joint fibrous capsules.[10] The fascial net is divided into three sections, the ventral, dorsal, and the myofascia sections.[10] The ventral and dorsal sections are separated by the spinal column.[10] The

myofascial section is the section that crosses both ventral and dorsal cavities.[10] The dorsal cavity holds connective tissue such as the dura mater, arachnoid later, and pia mater, and the perineural network.[10] In the ventral cavity contains items such as the bags that hold the heart, lungs, and abdominal organs.[10] Without these organ bags, there would not be a great way to hold an organ together.[10]

It is theorized that there is a system in place that intertwines the body and begins at birth.[10] This theory is the double bag theory.[10] This relates to the human locomotor and fascial systems in that there are two bags that surrounds the anatomy.[10] For example, one bag surrounds the bones and the other surrounds the muscles.[10] The muscle and the bone never touch, but there is a fascial connection from the muscle and reacts on the periosteum of the bone which allows for the two to work together to create motion.[10] Another example would be the joint capsule.[10] There is an encasing of the bone, called the periosteum, and there is a separate encasing of the ligaments and the joint.[10] It is all connected by fascia, but this connection is lost when it is dissected for evaluation.[10] This is all held together by an 'inner bag'.[10] The 'outer bag' in this example would contain the muscles of the joint.[10] With this, it is theorized that the human body only has one muscle, but with this double bag system, the body has about 600 pockets of muscles which creates the attachment points to bones and joints.[10]

There are a number of rules that apply to fascia and how it functions.[10] First is that these fibers run in the same direction.[10] These fascial lines provide structure and assist in direction and movement.[10] Examples of these include the superficial back line, the superficial front line, and the lateral line.[10] If there is a change in direction or a bend, then it must be a gradual change, otherwise the function of the structure changes.[10] An exception would be if there is a supporting structure, allowing for the change of direction, and the structure can assist in creating a motion.[10]

This would apply to muscles such as the peroneus brevis, as the malleolus provides a support for the peroneus to go underneath it and provide its function, but it is still considered one line.[10] The direction of fibers can also change based on where the limb is.[10] For example, the pectoralis minor and the coracobrachialis are two different muscles with different actions and their fibers would not be considered to go in the same direction while in anatomical position.[10] This changes, however, when the arm comes overhead, and these fibers actually lineup.[10] This would then create the deep front arm line, and also connects to the superficial front line.[10] This same rule applies to the depth of the tissue.[10] Those muscles with varying depths or with muscles going between them do not communicate or interact as well as those muscles that are on the same superficial or deep level.[10]

The second rule is that muscles are connected by bony attachments.[10] Basically, the muscle fibers are connected via the connective fascia discussed early, which attaches to the bone.[10] This rule is related to the previous rule of direction and depth.[10] The more superficial the structure is, the more communication there is with neighboring structures.[10] An example would be the relationship the scapula has with the muscles it attaches with. The serratus anterior, while a separate muscle from the rhomboids, shares a similar relationship due to its superficial nature and its attachments.[10] Conversely, the more deep a structure is, such as a ligament that connects bone to bone, there is little communication.[10] Their purpose is to connect structures, not to pull them together or to activate fibers, therefore, if there is less communication, this is considered to be more stiff, and less lax than if there was more communication.[10]

The third rule is how these structures may diverge or converge.[10] "Fascial planes frequently interweave, joining with each other and splitting from each other…"[10] One example would be the abdominal muscles.[10] These muscles originate at the same bony landmark, but they

diverge and change as the muscles split to perform different functions and attach to different places.[10] That is why we have several abdominal muscles.[10] While some muscles diverge, others converge in an area.[10] The pelvis is one example. Many muscles attach or cross over this area as the connector between the lower extremity and the upper portion of the body.[10] With this convergence, it is key to note the bony landmarks of the pelvis area, such as the posterior superior iliac spine and the anterior superior iliac spine relationship, to give you a good idea on where the fascia is tight.[10]

The fourth rule is related to singular or multi jointed muscles.[10] Generally speaking, the multi joint muscles, such as the Sartorius and the biceps brachii, have less to do with improper posture than the singular jointed muscles do.[10] This can be useful when the clinician is assessing for tight spots that are not released by treating the larger and most superficial muscles.[10]

The hamstrings and the back extensors are contained in the superficial back line (SBL).[10] It is a two piece unit with knees flexed, and one piece with knees extended. It connects the posterior portion of the body, one piece going from the bottom of the foot in the plantar fascia to the knees, and then the knees to the brow.[10] The SBL is meant to provide support with extension to the full body, and to prevent the body from excessive flexion.[10] When there is a problem with the SBL, there might be hyperextension present.[10] Due to this endurance function, there are a higher number of slow twitch fibers in the SBL myofascial tissue as well as dense tissue in the fascial tissue.[10] The SBL also provides stability at the knees, supporting the cruciate ligaments while standing.[10]

The SBL can be broken down into two longitudinal halves, one on the left side, the other on the right.[10] One can have an imbalance and be corrected while the other is healthy.[10] Its postural abnormalities can be described as:

Common postural compensation patterns associated with the SBL include: ankle dorsiflexion limitation, knee hyperextension, hamstring shortness (substitution for inadequate deep lateral rotators), anterior pelvic shift, sacral nutation, lordosis, extensor widening in thoracic flexion, subocciptial limitation leading to upper cervical hyperextension, anterior shift or rotation of the occiput on the atlas, and eye-spine movement disconnection.[10]

The SBL runs from the toes to the head.[10] It includes the plantar fascia which can cause problems all the way up the chain.[10] It attaches to the Achilles Tendon which contains tendons of the soleus and the gastrocnemius.[10] The train continues with the hamstrings.[10] From here there are many branches of the train, creating separate muscles and functions.[10] From the hamstrings, the fascial line is continued with the sacrotuberous ligament, which continues into the sacral fascia, and continues unto the erector spinae muscles.[10] The next portion of the SBL is the subocciptial muscles.[10] The SBL continues up over the head to blend into the galea aponeurotica of the skull, and finally attaches and ends at the frontal brow ridge.[10]

HAMSTRING

The hamstring is a common muscle to strain and can lead to loss of playing time at any level of sport.[14] For example, hamstring strains are common in soccer players due to the high intensity[14,15,17,23], but they are also common in dancers with improper stretching.[14] Woods et al.,[17] found that they were the second highest in occurrence rates next to knee sprains in English premier soccer leagues.[14] It is estimated that a hamstring strain can lead to missed playing time that could equal up to 3 weeks of inactivity.[14]

There is evidence that shows that age and decreased ROM increases a person's chance to sustain a hamstring injury.[14-16] While general hamstring stretches can help increase ROM with

time[24], Bradley et al.[15] suggested that stretching prior to practice may decrease power capacity of the hamstring. As a result, other methods are needed to quickly increase ROM in order to decrease hamstring injury rates, while maintaining hamstring muscle power.[15] At this time, there is some evidence that utilizes IASTM to change a patient's PSLR.[7] Markovic[7] found that a two minute treatment with a form of IASTM, called Fascial Abrasion Technique, after a dynamic warm up is effective in increasing hamstring ROM. Their patient population were physically active and started with about 75° of PSLR which they defined as going until a firm end feel was detected.[7] They followed a similar timeline to this study where they receive treatment and then followed up 24 hours later to investigate the short-term changes. Barger performed a four-minute GT treatment on active cheerleaders and found that this treatment with GT1 allowed for significant ROM findings.[25] Their pre-test PSLR values were 90° which was measured at the patient's end feel.[25] Moon et al.[26] reported evaluating hamstring ROM and its relation to nonspecific low back pain. They did not report average PSLR criteria, but one of their inclusion criteria were a PSLR of 70° or less.[26] They did not have a requirement for physically active participants.[26] They treated the hamstring in a semi-flexed positioned between 30-60° while applying GT1.[26] Baker et al.[27] evaluated the use of IASTM in treating those with tissue extensibility dysfunction. They found three case studies of college aged athletes where they applied IASTM treatment while also applying a passive force.[27] These patients received treatment three times per week until discharge.[27] Patient one was a 19-year-old male cross-country runner and started with a PSLR of 38° and increased ROM to 90° after four weeks of treatment.[27] Patient two was a 21-year-old female swimmer, and started her treatment with 45°.[27] By the time treatment was completed four weeks later, she was able to reach past 100°.[27] The third patient was a 22-year-old cross country runner who started out at 74° of PSLR, and was

able to progress beyond 85° of PSLR by the completion of treatment two weeks after treatment initiation.[27] Two of these patients would align with our study's average hamstring ROM measurement.[27] Three of the four studies above use a population that is physically active. The ROM measurements in our study were reduced compared to these studies, but this could be accounted for as the above studies went to end ROM for their PSLR compared to our study which was measured to first resistance (R1).[28] This was chosen to maintain as much consistency between PSLR as possible as people have different perceptions to what they think is their end feel.

INSTRUMENT ASSISTED SOFT TISSUE MOBILIZATION

Instrument assisted soft tissue mobilization (IASTM) is defined as a non-invasive soft tissue mobilization that helps to locate and treat soft tissue lesions.[29,30] It is based on the James Cyriax approach, using specific solid instruments to alleviate pain, functional limitations, and impairments associated with muscular dysfuction.[4,13,31-33] These instruments can be used to increase range of motion (ROM), prevent scar tissue formation, and produce an inflammatory response.[4,5,13,32,33] It is growing in popularity, with an assortment of instruments available.[34] An additional benefit of the use of instruments is the advantage to the clinician.[35] The instruments take pressure off their hands, as well as provide a mechanical advantage to help with the treatment goal.[4,35]

One specific set of instruments used in conjunction with a set protocol and certification, is called the Graston Technique®.[6] The instruments are named GT1-GT6 and each have a separate purpose.[6] GT1 instrument is a long instrument with a concave treatment edge, with 2 convex angles,[6] that is used to scan and treat large muscle groups.[6] GT2 is a smaller instrument meant for smaller muscles and treatment spots.[6] It has two ends, one single beveled and one

double beveled edge, with two points on the ends.[6] It can sweep or scoop treatment areas with one hand or two.[6] GT3 is a single beveled pill shaped instrument with convex treatment edges.[6] It is meant for pin point application.[6] GT4 is a single bevel edged instrument with a thick midsection and shorter ends.[6] It is meant to fan, scoop, or sweep tissue.[6] GT5 is a thin curved instrument with a single beveled edge.[6] It is meant to be used as be a more aggressive scanning device and can scan, sweep, swivel, or scoop.[6] GT6 is a shorter version of GT2, with more pronounced angles and edges which can treat smaller areas such as a wrist.[6] It has a single and double beveled edge with one sharper treatment tip, and one duller treatment tip.[6] It can sweep, brush, scan, scoop, and swivel.[6] The instruments are designed with beveled edges that help to detect and break down adhesions.[36] These edges also help to monitor the depth and the dosage applied to the patient in order to stay within treatment guidelines and patient tolerance.[4] These instruments do not replace the clinician's hands, however, rather they provide an extension of their hands which can detect adhesions and trigger points better than the hands alone.[34,36,37]

A myofascial trigger point is defined as a palpable nodule that is hypersensitive within a taut band of muscle.[38,39] They can develop from physical activity or new movements, as well as poor posture.[40] Treating these nodules is called myofascial therapy, which is a form of manual therapy, and it is the "facilitation of neural, mechanical, and psychophysiological adaptive potential as interfaced via the myofascial system."[41] Another way to treat myofascial and musculoskeletal conditions is with friction massage.[42] The goal of friction massage is to help with pain, decrease scar tissue and adhesions, as well as increase hyperemia.[42]

As stated previously, hamstring ROM will be measured as a passive straight leg raise (PSLR).[7,24]

THEORY OF IASTM

The theory on treating musculoskeletal conditions begins with James Cyriax, where he describes a massage as restoring muscle function by realigning the muscle fibers.[13] When the clinician detects a lesion, assessment of the patient's tolerance to the treatment is key, as they are able to feel the vibration from the instrument cross over the adhesion.[4,9] The treatment helps to break up adhesions by spreading the fibers.[4] This treatment can also begin the inflammatory process of a muscle, to help it rebuild the muscle.[4,5,33] There has been evidence that would suggest this process does occur, and they have had several positive outcomes while utilizing GT.[5,33,36] Prentice et al.[43] and DeLuccio[4] both hypothesize that after these instruments find a lesion, then the clinician is able to initiate the healing process for the tissue to heal faster due to the micro trauma that is provided by the instruments. This micro trauma then in turn is hypothesized to increase pliability and extensibility, as well as separate the adhesion from the healthy tissue.[36]

Chaudhry et al.[44] provided a mathematical model to show how much force is necessary to cause true tissue deformation in dense fascial tissue such as the plantar fascia and the fascia lata. They say true tissue deformation is outside physiology range that perceived change is neurological in nature.[44] Bialosky et al.[12], however, says that there are multiple mechanisms that can alter the tissue from manual therapy. They created a comprehensive model that shows the many ways that manual therapy effects the tissue from multiple mechanisms.[12] They emphasized that manual therapy, regardless of the treatment, will affect everyone differently.[12] The authors tried to show that it is difficult to know the true nature behind the change in tissue regardless of the pressure or the type of treatment.[12]

While there is a theory that there is a physical affect that occurs in the tissue, there is an argument that it doesn't necessarily come from a physical reaction, rather a neurological reaction. This comes from the discovery that the largest number of sensory nerves are within the myofascial tissue.[11] This would lead someone to believe that sensory input is more important than fiber organization.[11] Robert Schleip[44] concluded that stimulation of the Ruffini organs and the interstitial receptors trigger changes to the autonomic nervous system. Ruffini organs are receptors that respond to long term pressure, and interstitial receptors are located within the muscle or fascia tissue.[44] Bialosky et al.[12] also concluded that there was a neurological component that went into tissue reaction from manual therapy. According to his model, pain modulatory circuitry from a stimulus leads to an autonomic response to the body such as skin temperature changes, skin conduction, cortisol level changes, and heart rate changes.[12] It can also lead to a placebo effect or some other psychologic response such as fear from being hurt, catastrophizing, and kinesiophobia.[12]

While there have been studies to show a fibroblastic response in the tissue after an IASTM treatment[5,33], there have been other authors that try to apply these techniques to other pathologies and structures other than myofascial tissue.[34,45,46] Sandrey and Schaefer[45] hypothesized that applying GT to those that suffer from chronic ankle instability would help increase stability. They noted that those that had dynamic balance training and GT made the largest improvements.[45] Loghmani et al.[46] hypothesized that GT would augment healing in a rat MCL tear. While they noticed a positive response with a stiffer and stronger ligament than the control group, the ligament was still subpar to the uninjured MCL, and it did not actually help with the overall healing time.[46] Burke et al.[34] tried to utilize GT with carpal tunnel syndrome. They hypothesized that with the increased joint motion from the treatment, the ischemic effects

would be alleviated by an increased blood flow to the vasa nervorum, therefore decreasing symptoms of carpal tunnel syndrome.[34]

PATHOLOGIES TREATED

GT and other IASTM instruments can treat a multitude of different conditions. They can treat conditions including but not limited to fascia, scars, entrapments neuropathies, edema, and lymphedema.[4,6] Patient tolerance, healing stage, tolerance, and structural tolerances will dictate your treatment plan.[4,6]

There has been conflicting evidence as to whether IASTM is beneficial. Crothers et al.[3] tried to treat low back pain, however they did not find a statistical significance between their groups. There were three group including a spinal manipulative therapy, GT, and a placebo treatment. They concluded that treating low back pain as a homogenous condition was the key factor here, where the clinician does not change their treatment plan based on their response.[3] Burke et al.[34] investigated carpal tunnel syndrome with a GT intervention, and concluded that their effects were immediate and outcomes lasted at least 3 months post treatment. Laudner et al. investigated a shoulder ROM protocol, and concluded that they found clinically significant results that after one treatment, there was an increase in ROM.[47] Brantingham et al.[30] decided to look at patellar femoral pain syndrome, and whether GT would be beneficial to decrease pain levels. They found clinically meaningful results that showed that at the 2 month follow up, pain levels were less than baseline.[30] Blanchette et al. examined the effect GT would have on lateral epicondylitis, and did not find significant results with their intervention.[37] Gulick et al. did not find any significant findings when they applied GT to myofascial trigger points.[40]

VARIABLES

The most common dependent variables are muscular ROM and the visual analogue scale (VAS) for pathologies treated. [7-9,29,36,45,47-49] This is due to the high number of muscular and pathology focused studies.

The two independent variables in this study are the amount of pressure applied to the treatment area and time. While there is some evidence to support that pressure changes make a difference in treatment outcomes,[48] there are other authors who conclude that pressure changes need to be evaluated in future research.[7,27,37,50] The dependent variables of this study were hamstring PSLR and a VAS scale.

CONSENSUS

The most common consensus across studies is that there is a high variability of treatment protocols, pathologies treated, instruments used, and timelines.[7,19,47,48,50,51] Some reviews[9,19,35] have been conducted to help establish validity of IASTM and the differences between them to establish the best course of action, but the challenge is posed that you cannot compare studies when they vary in nature. This problem is then presented to the reader who has the challenge of making a clinical decision with variable information.

While there is high variability with methods, protocols, and treatment instruments, there are some consistent consensus statements across the literature. One, the therapy should depend on the patient, the pathology, and resources available.[19] Two, it is difficult to say with the evidence provided to ascertain the effects of IASTM or GT. [30,34,37,40,45] The treatment protocols vary in many studies, with various pathologies treated, it is difficult to genuinely assess the effect of the treatment protocols. [30,34,37,40,45] Cheatham et al. found through a systematic review that there is weak evidence to support the usefulness of IASTM for affecting lower extremity ROM

for short periods of time.[9] They also found that the current evidence does not support using IASTM to treat some musculoskeletal pathologies.[9]

PURPOSE

The purpose behind this study is to study the difference between ROM gains after applying the GT in varying pressures. There has been speculation and discussion about how there needs to be evidence in regards to the varying amounts of pressure.[36] Evidence has shown differences in tissue response with varying amounts of pressure, but very little research has been released since that article.[5] More recent research that discusses pressure points out how there is little consistency between researchers and protocols.[19,35] This creates a problem with clinical application and knowing which is more clinically beneficial. A second problem is the lack of consistent rehabilitation protocols where GT is implemented. No two research articles have the same protocols. This can lead to inconsistent clinical application, misinterpretation, and misuse. There is also a high incidence rate of hamstring injuries due to decreased ROM and athletes not being able to complete the season due to this injury.[15,16,23,52,53] A patient requires adequate ROM to have full function of this joint and body part. Knowing which pressure is sufficient in increasing ROM will help to eliminate compensation injuries, injuries to the joint with the decreased ROM, decreases chances of hip dysfunction, and allow for full use of the joint.[24,27] The reasons for a need for full ROM continue to grow with research.[24]

CHAPTER III: METHODS

STUDY DESIGN

A randomized control trial was conducted in a university laboratory to assess how changes in pressure during a GT application affect hamstring ROM. Our independent variables were group (control, firm pressure (FP), and light pressure (LP)) and time (Baseline, post-intervention, and 24 hours post-intervention), and our dependent variables were PSLR and VAS scores. PSLR was measured at all three-time points, where VAS was only recorded at baseline and 24 hours post-intervention.

PARTICIPANTS

A total of 28 participants volunteered for the study, with 1 lost due to having more than 70° of PSLR, for a total of 27 participants included in the study (14 females and 13 males, age: 22.85±3.38 years; height: 174.23±8.43 cm; weight: 83.6±30.79 kg). Participants were excluded if they had a PSLR as measured as R1 greater than 70°, suffered a lower extremity injury in the past 6 months, received any medical treatment to the lower extremity in the past 6 months, had manual therapy treatment in the past 6 months, or had a history of lower extremity surgery. To be included in the study, participants had to be between the ages of 18-35 and physically active, as defined as 1-5 hours of moderate intensity physical exercise 3-4 times per week.[24] This measurement was taken at the first point of resistance during the PSLR assessment. All participants received an informational sheet on hamstring stretches to educate them on hamstring flexibility. This was used to blind the control group from group allocation, as well as blind the research assistant from group allocation.

INSTRUMENTATION

A digital inclinometer (SPI-TRONIC Pro 3600) was used to measure the PSLR. It was calibrated on the same surface before every measurement and placed on the anterior upper thigh, superior to the patella for each participant in order to create an angle that was parallel to the table from the inclinometer.[7] GT instruments were used to provide treatment following the recommendations from the M1 course. The specific instruments used in this study were GT1, GT5, and GT4 (Graston Technique, LLC, Indianapolis, IN). GT1 was used to scan and detect lesions in the muscle. GT5 was used to further identify lesions in the muscle tissue and reach the medial portion of the hamstring. Pressure during part of the treatment was recorded using the MotionMonitor Manual Therapy Product (Innovative Sports Training, Inc, Chicago, IL). A plastic wedge was secured to GT4 and Velcro strips secured the wedge to the Manual Therapy Product sensor. GT4 was the only instrument where pressure was measured. This was due to the transducer of the Manual Therapy Product being limited to one-handed use and being best with a level surface. There were two pressures used and measured in this study, light and firm pressures. Light pressure was applied between 1.1-3.7 Newtons (N), and firm pressure was recorded between 3.5-10.7 N during each treatment stroke while applying GT4. Reliability was measured after completion of data collection. ROM measurement was determined to be of excellent reliability (α=0.9), light pressure was determined to be of acceptable reliability (α=0.79), and firm pressure was questionable (α=0.64) as determined by Cronbach alpha levels.[54-56]

TREATMENT APPLICATION

Participants were randomized into one of three groups: LP, FP, or a control group that did not receive treatment with the instruments. Randomization occurred prior to participant

recruitment using block randomization. Participants in all groups began the protocol in athletic shorts. All groups were given an informational sheet on hamstring stretches and were given a chance to ask questions. This allowed the subject to wait the same 6-minute period as those in the two pressure groups, further blinding the research assistant. Participants were not allowed to practice the stretches at the time and were instructed to wait until after follow-up to begin any stretching protocol.

The GT treatment was administered in a separate room adjacent to the laboratory and the research assistant was not in the room during the treatment. The patient was instructed to lie prone on the treatment table with their knee fully extended. There were two pressure groups, FP and LP. For both FP and LP, emollient was applied to the treatment area using the clinician's hands to decrease friction and increase comfort level for the participant. The same clinician applied all GT treatments, and the same instrument protocol was applied for both LP and FP with the exception of the amount of pressure applied. GT1 was used for a total of one minute from the distal portion of the hamstring to the proximal portion of the hamstring using a scanning stroke. Then GT5 was used for one minute to further identify adhesions and trigger points, again using a scanning stroke. This pressure was applied with a pressure that was judged by the clinician to be medium pressure. It was applied so the pressure was not the same as firm or light pressure application from treatment that occurred while applying GT4.Next, GT4 was utilized to treat the muscles for two minutes with two different pressure applications as delegated by their randomization into groups. This section of treatment was the only time we directly measured pressure. GT4 was scanned across the posterior thigh in four sections for 30 seconds each to ensure total coverage of the hamstring muscle group. These sections were divided as lateral, lateral-medial, medial-lateral, and medial in order to treat the entire muscle group. Strokes used

were the fan and sweep in multiple directions. The FP group received a firmer application, ranging from 3.5-10.7 N depending on the size of the patient's hamstring as well as clinician error. The LP group received treatment application ranging from 1.1-3.6 N. After this two-minute treatment period for both groups, GT5 was used for one minute and GT1 was used for one minute to complete treatment. Strokes used were fan and sweep for both instruments. This pressure was applied with a pressure that was judged by the clinician to be medium pressure. It was applied to treat remaining adhesions with pressure that was not the same as firm or light pressure application from treatment that occurred while applying GT4. This was so that the remainder of the treatment was the same across the study and the only difference was the measured pressure differences from GT4. Once treatment was complete, the participant changed into long athletic pants and was instructed to not say anything about the treatment or the information received to the research assistant. This allowed the research assistant to remain blinded to group allocation. After treatment, the participant was released to perform exercises with the research assistant.

PROCEDURES

Participants were recruited via email, classroom announcements, and word of mouth. Informed consent was obtained from each participant before being evaluated for inclusion and exclusion criteria. Each participant was evaluated for inclusion and exclusion criteria and asked to fill out a pre-treatment questionnaire. The pre-treatment questionnaire included questions about demographics, physical activity, previous pertinent injury history, and included a VAS scale[37] to rate pain before treatment was applied. Eligibility was determined from this questionnaire and also using a PSLR of their dominant leg measured before treatment to eliminate any cross over effect. The dominant leg was determined by asking the patient which

foot they used to kick a ball. The non-dominant leg was stabilized to the table by the same investigator who applied treatment. Participants were eligible with a PSLR of 70°of flexion or less at the first point of resistance (R1).[28] This allowed consistency in ROM measurements across participants. The same research assistant performed all PSLR measurements and this research assistant was blinded to group allocation. Randomization occurred before the participant was screened for inclusion criteria. After inclusion criteria were met, the participant completed a 10-minute bike warm up. This was followed by the designated group treatment of either control, FP, or LP. Next, all participants completed high repetition, low load exercises[6], which are pictured in figures 1-3 below. Exercises performed were bilateral Romanian dead lift (RDL's), prone hamstring curls, and heel slides. Two sets of 15 repetitions were performed of all exercises. There were about 30 seconds in between exercises and 15 seconds in between sets. Participants were asked to perform exercises at a 3 second pace. RDL's were performed with a dowel rod for form assistance. They were asked to keep their knees slightly bent without arching their back. One repetition occurred once there was a hinge motion at the hips and the dowel rod was lowered to reach mid shin and completed by extension of the hips to bring the patient to a standing position. The next exercise was the prone hamstring curl, which was performed on the same leg as the treatment. The participant was prone on a treatment table with a blue Theraband® (Theraband®, Akron, OH) around the ankle held by the research assistant. This gave a maximum of 5.8 pounds of resistance when stretched to 100%.[57] The subject was then asked to flex their knee to bring the heel to their buttocks. The next exercise was a heel slide. The participant was supine and they were asked to bring the heel of the treated leg as close to their buttocks as they could. Participants wore socks to allow for a more fluid movement with less resistance.

Figure 1. *Starting point of the RDL*

Figure 2. *End point of the RDL*

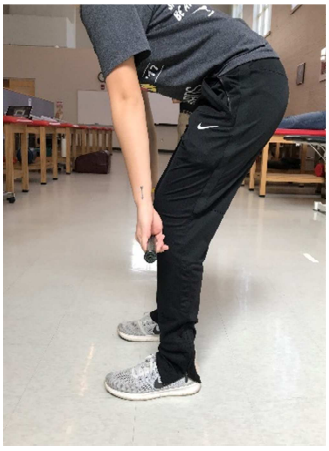

Figure 3. *Starting position for the Hamstring curl*

Figure 4. *Starting position for heel slides*

Figure 5. *End position for heel slides*

Following the exercises, the research assistant performed 3 sets of hamstring stretches, each lasting 30 seconds. Hamstring stretches were performed as static hip flexion with knee extended of the treated leg which was stopped after a firm end feel was detected, or once the opposite extremity began to move.[24] The non-treated leg was stabilized by the same clinician who performed the treatment. End range is different from the first point of resistance used for ROM measurements. The goal with end range is to maximally stretch the muscle within the patient's comfort. Once the exercises and stretches were completed, the research assistant performed a second PSLR as the clinician who performed the treatment stabilized and applied the inclinometer. The average of three PSLR trials were recorded. After this was completed, the participant was thanked and asked not to take unnecessary pain medication, drink alcohol, or

exercise before the 24-hour period was completed in order to limit the number of confounding variables. Follow up was conducted 24 hours later.

FOLLOW UP

Follow up occurred 24 hours later using the same parameters as initial baseline. They were instructed to wear long athletic pants again to blind the research assistant to skin reactions. Before measurements were taken, they were asked to complete a post treatment questionnaire, which included a VAS scale describing the pain felt in the hamstring from treatment. They were asked how they felt after treatment and if they complied with the instructions from the day before. They were asked to lay supine on the table with the non-treated leg stabilized to the table by the same investigator used as the initial measurements. Then the same research assistant who measured the ROM the day prior measured the participants' PSLR. The participant was thanked for participation and was issued an ice bag if they desired.

STATISTICAL ANALYSIS

The means and standard deviations were calculated for all variables. To compare the effects of the intervention, a mixed, between-within subjects ANOVA was used to compare PSLR across groups over the 3 time points. The VAS score change was analyzed with a Kruskal Wallis Test. All statistical analyses were performed using SPSS (SPSS version 22, New York, NY).

CHAPTER IV: RESULTS

Descriptive statistics for the PSLR are reported in Table 2. There was no significant interaction between treatment group and time, Wilks' Lambda= .860, F (2, 23) = .899, p=.472, partial eta squared= .072. There was also no significant main effect for time, Wilks' Lambda= .909, F (2, 23) = 1.157, p= .332, partial eta squared= .091, with none of the groups showing a change in ROM across the three-time periods. The average pressure applied for the firm group was 6.43±2.38N and the average pressure applied with the light pressure was 1.68±0.83N. There was no significance between groups VAS scale showed no significance between groups ($\chi^2(2) = 3.61$, $p = 0.17$).

Table 1. Descriptive statistics for PSLR results measured in degrees (mean ± SD)

	n	Pre-intervention	Immediate post-intervention	24 hours post-intervention
Control	9	44.5±9.13°	48.00±8.80°	45.28±8.5078°
Firm	9	48.9074±10.34°	48.02±12.43185°	45.3704±14.73°
Light	9	41.2593±9.54°	42.85±5.4319°	42.5±13.09°

Table 2. VAS scores (mean ± SD)

VAS Change		
Pressure	Mean	N
Control	0±0	9
Firm	0.66±1.12	9
Light	0.056±1.13	9
Total	.2407±0.93	9

CHAPTER V: DISCUSSION

The purpose of this study was to examine how varying levels of pressure during a GT treatment affected hamstring ROM as measured with a PSLR. Our main finding was that there were no differences in ROM for any group immediately or 24 hours after intervention.

To the authors' knowledge, this is the first study to investigate hamstring ROM changes following a GT treatment with varying pressure. There is very little evidence to tell clinicians how much pressure to apply to provide a therapeutic dose.[5,33] GT recommends a gradual increase in pressure application over time, beginning with an introductory treatment before becoming more aggressive with consecutive treatment sessions.[6] While this is a good place to begin, this recommendation could be more specific in regard to how much pressure to apply. While we measured our pressure, to translate to general application it could be said that the pressure applied is similar to firm pressure causing the instrument to be deep in the muscle tissue. Recent research has developed a formula to predict the amount of pressure that is needed in order to cause true tissue deformation of dense fascial tissue, and those authors concluded that the forces needed were outside of normal physiological range.[44] There have also been models developed to assist in showing all the possible physiological stimuli that can cause tissue tensile changes.[12] A study published in 2014 used pressure as a variable to provide consistent pressure during a one-time application[54], however our investigation was the first to focus on the effects of two different pressure applications on hamstring ROM.

There have been a few studies to show the effect of GT on ROM. Launder et al.[47] evaluated shoulder IR with application of GT for 40 seconds and showed an increase in shoulder horizontal adduction by 11.1° and internal rotation by 4.8°. Markovic[7] examined hip ROM using IASTM and foam rolling for two minutes and found an increase in hip ROM by 13-15°

immediately after treatment. They evaluated ROM 24 hours later and found they maintained an increase of 9-10° of hip ROM.[7]. Vardiman et al.[54], however, applied a 7-minute treatment of GT on the plantar fascia and showed no significant findings in ROM, stiffness, or strength, which aligns with our results. The differences in these findings could be explained by many factors. One theory is treatment time as the two significant outcomes had less treatment time[7,47], while ours and Vardiman et al.[54] had a longer intervention time. The longer treatment time with GT potentially caused more inflammation to the muscle tissue.[5,19,33,37] The superficial back line (SBL) is the anatomy train in the posterior portion of your body and is designed as an endurance tissue, as a result of holding the body upright, and this would require a large amount of force in order to produce physiological changes.[10,44]

Hamstring mobility is extremely important in regard to decreasing injury or pain for the patient.[8,14,15,17,23,26] It has been shown to contribute to low back pain[8,26] as well as an increased risk of hamstring strains.[14,15,17] There has been research performed on hamstring ROM with GT, IASTM, and self-mobilizing treatments using multiple protocols and application styles. While pressure was not a variable in any of these studies, many showed promising results in terms of being able to increase ROM in a variety of ways.[7,25,26,30] One thing to note is many hamstring studies had a higher pretest ROM value than this study due to what that author defined as end range. We chose R1 in order to remain consistent across the study, but there are a few studies that continued to end range and reported higher values with the PSLR.[7,25,26] While the results from this study do not support the use of GT to increase ROM, current hamstring research shows benefits to the use of IASTM and GT in a variety of application techniques. This variety includes foam rolling,[7] treating the hamstring while flexed in a relaxed position,[26] and scanning the whole muscle to decrease muscle tension.[25] The problem with these different protocols and methods is

that while it is good to show significance with the treatment, it makes it difficult for clinicians to make application decisions. One of the biggest benefits to GT in that it has a set protocol in place to establish homogeneous treatments. For the hamstring, they recommend having the patient prone and have the knee in various angles while applying it to the tissue.

One difficulty in comparing our findings to those of previous GT investigations involves the full use of the GT protocol and consistent application of the treatment. A number of previous studies have not used the full GT protocol.[7,8,25,26,47,48,51] However, while these studies did not follow the protocol, there were a number of studies that did and still yielded a statistically significant result.[30,36,37,40,45,50] The full GT protocol includes five basic components.[6] First, you begin with a soft tissue warm up using cardio or modalities. Second, you apply the treatment to the desired area using the appropriate instruments. Third is to stretch the tissue. Fourth is to do a strengthening program with high repetition and low load exercises. Finally, you can end the treatment with cryotherapy application if desired. There are a number of studies performed that neglected to use the GT protocol, but some studies aligned their methods with the GT protocol and yielded statistically significant results.[30,36,37,40,45,50] These studies used interventions that lasted 4-6 weeks and focused on increasing ROM[8,36] or treating a pathology over the course of the treatment.[36,50,58] This lack of protocol consistency across all GT studies makes it difficult to draw conclusions based on results. This statement is consistent with Cheatham et al.[9] who concluded that the evidence they evaluated provided weak research to promote IASTM as a result of protocol inconsistency.

It was hypothesized that there would be an increase in hamstring ROM after receiving GT with firm pressure, compared to the group with light pressure or the control group. There has been evidence showing that a stimulus to the muscle will cause a change in the tissue regardless

of the type of mechanical stimulus.[11,12] Bialosky[12] previously has shown that there could be multiple reasons why people respond differently to treatment and gave guidance to possibilities as to why manual therapy is effective. This model proposes how different stimuli communicate with different neurological pathways to cause various responses.[12] It shows that there is really no way to know for certain where the stimulus reaction is coming from.[12] For example, a branch of this model focuses on mechanical stimulus to the tissue, which then either allows for the tissue to have a decreased spasm and increase in range of motion, or there is a signal sent to the peripheral nervous system causing an inflammatory response.. This applies nicely to a conclusion some studies made, which is that treatment must match the person.[12,19,35] Through the evaluation and clinical judgement, clinicians usually can apply the treatment that will work best for the patient, but this can be different patient to patient.[12]

With our results showing there was no real change in the tissue, which is in contrast to prior research showing there is an immediate change[7,47], there could be speculation this patient population did not respond to the treatment presented due to a number of reasons. One reason could be due to the instruments used. A few of the studies that yielded positive results used only GT1 whereas we used GT1, GT 4, and GT5.[25,26] Another possibility is that the tissue was going through an inflammatory response from the firm pressure application. Those who underwent light pressure might not have received enough stimulus from the instruments to cause any reaction. We chose a sample of patients that had not had GT performed in at least 6 months, so the tissue might not have been adjusted to the stimulus, causing guarding and inflammation.[4,12,20] A third possibility is the participant might not have had tightness due to the musculature, but rather something else within the leg or posterior chain.[12] This could be a tight hip capsule or an abnormal neuromuscular response.[12]

There were a number of limitations to this study. The first was the small sample size for a three-group study. A second limitation was that this was a convenience sample with individuals who are aware of what the GT is and possibly inserting unknown bias. Next, while every effort was taken to eliminate bias from the clinicians, patients, and the research assistant, it was still possible for bias to play an impact on the results. Another limitation is the recent release of the Manual Therapy product. It is a new device that made it difficult to know if the pressure it was reporting was from my hand trying to grip the instrument or from the actual pressure application. This, along with inconsistencies from the clinician and the way we connected the instruments to the device, was a large limitation to this study as we need to learn more about the product. Next, our starting ROM values were much lower than those in previous studies. This could be accounted for as we chose to stop and record measurements at R1 compared to end range. This could potentially account for the lack of ROM gains even after applying a stretch. Last, this was only a one-time intervention. It would have been interesting to see the differences in results if we used more treatments across time as previous research had done.[30,34,37,40,45]

While this study was not able to provide any statistical significance, further research needs to be conducted to investigate the effectiveness of pressure differences. There is a lack of evidence surrounding this variable, but it is important to know how much pressure is necessary for clinicians to provide the best care as efficiently as possible.

CONCLUSION

In conclusion, this study does not show differences in hamstring ROM following the full GT protocol while assessing different intervention pressures. There were also no changes following stretches. This could be due to multiple reasons such as inflammation in the area of application, PSLR deficits not coming from the hamstring, but coming from another source such

as a tight posterior chain in general, or the patient needed a different treatment to increase their ROM. The biggest controversy in the research is the lack of consistency among protocols, making conclusions difficult. More research must be done to investigate the full nature of pressure differences while applying GT. There is still a need to understand the full reactions of the tissue when applying different pressures in order to know how much is necessary to create a response. There is also a need to have more consistent application techniques.

As there is inconsistent evidence to support the application of GT to improve joint ROM,[7,8,25,26,47,54] clinicians should continue to apply these techniques as they see fit for their patient and the resources available to them.[12]

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