THE EFFECT OF THERAPEUTIC ULTRASOUND AND INSTRUMENT
ASSISTED SOFT TISSUE MOBILIZATION ON MUSCLE CONTRACTION
OF THE LUMBAR MULTIFIDUS MEASURED BY ULTRASOUND
IMAGING

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Degree of Doctor of Physical Therapy

By
Madeline R. Holman and Curtis Caldwell
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Effect of US and Graston on Muscle Contraction

**APPROVAL SHEET**

This independent research is submitted in partial fulfillment of the requirements for the degree of Doctor of Physical Therapy

____________________________
Madeline Holman

____________________________
Curtis Caldwell

Approved: April 2015

____________________________
Dr. E. Shamus PhD, DPT, CSCS  
Committee Chair

____________________________
Dr. A. van Duijn, EdD, PT, OCS  
Committee Member

The final copy of this independent research has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.
Effect of US and Graston on Muscle Contraction

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ABSTRACT

**Context:** Therapeutic ultrasound and Instrument Assisted Soft Tissue Mobilization (IASTM) are widely used physical therapy interventions used in a variety of orthopedic pathologies. The immediate effects of both interventions on muscle size and contractibility have not yet been established. There is limited clinical research regarding the immediate physiological effects of therapeutic ultrasound (US) or IASTM on muscle tissue.

**Objective:** To determine the immediate effects that therapeutic ultrasound and the IASTM Technique have on muscle contraction of the L5 multifidus in healthy individuals as measured by diagnostic ultrasound imaging.

**Design:** Quasi-Experimental Design

**Setting:** Data collection took place in the Florida Gulf Coast University Physical Therapy Lab.

**Participants:** 25 healthy individuals (11 male, 14 female) ages 18-45 years. No history of current or previous episodes of low back pain, no prior spinal surgeries, and no history or diagnosed spinal deformities, neuromuscular conditions, joint disease, malignant tissue, or currently pregnant.

**Interventions:** Participants were treated with 10 minutes of therapeutic ultrasound on the right L5 multifidus with the following parameters: 1-MHz continuous ultrasound at an intensity of 2.0 W/cm². During the final 2 minutes of the ultrasound treatment, participants were also treated with the Graston on the left L5 multifidus.

**Main Outcome Measures:** Cross sectional area of the left and right L5 multifidus were measured in both a relaxed and contracted state prior to and following treatment.
Three images were taken in each state and the average cross sectional area was used for data analysis.

**Results:** This study found no significant differences in the cross sectional area differences of the L5 multifidus muscles in the relaxed muscle and contracted muscle before and immediately following therapeutic US and IASTM using the Graston Technique.

**Conclusion:** Although the results of this study found no significant difference in the immediate effects of both therapeutic US and IASTM on the cross sectional area of the lumbar multifidus muscles during relaxed and muscle contraction as measured using diagnostic US, further research is recommended to examine the long term physiological effects of these treatment interventions on the lumbar multifidus muscles after various increments of time following treatment.

**Keywords:** Instrument assisted soft tissue mobilization, therapeutic ultrasound, diagnostic ultrasound, cross sectional area, lumbar multifidus
INTRODUCTION

Ultrasound and instrument soft tissue mobilization are used to treat a variety of conditions: low back pain, sprains, strains, plantar fasciitis, trigger thumb, arthrofibrosis, and many others. Ultrasound is the use of sound waves to treat various medical conditions. Sound waves are created by applying a high-frequency alternating electric current to a crystal in a transducer. This creates a sound frequency that is much higher than what humans can hear and is absorbed by the soft tissue creating heat.\(^1\) It was once thought that the physiological effects of therapeutic ultrasound were well understood, however newer research is questioning the once believed benefits of this therapeutic intervention.

IASTM is a form of soft tissue mobilization that uses tools to break up areas of scar tissue, adhesions, and fascial tightness. It is proposed that using instruments for the application of soft tissue mobilization allows for controlled application of friction massage to the targeted treatment area as well as gives the therapist a mechanical advantage greater than provided from manual soft tissue techniques. A better mechanical advantage allows for deeper penetration and possibly better specificity of the treatment.\(^2\)

There is little research analyzing the immediate physiological effects of Ultrasound and IASTM have on muscle contractibility and therefore it is important that research be conducted in order to better the benefits of these treatment methods.

PURPOSE

The purpose of this study was to determine the immediate effects that therapeutic ultrasound and IASTM have on the cross sectional area of the L5 multifidus before and after treatment when the muscle is both relaxed and contracted. The research question
was: Will there be a difference between the contracted and relaxed cross-sectional area of the multifidi at the L5 level before and after using therapeutic ultrasound or instrument assisted soft tissue mobilization as measured by diagnostic ultrasound imaging.

There were two hypotheses for this study:

1. It is hypothesized that using IASTM will increase the cross-sectional area of the multifidi at the L5 region following two minutes of treatment.

2. It is hypothesized that using therapeutic ultrasound will increase the cross-sectional area of the multifidi at the L5 region following 10 minutes of continuous ultrasound at 1Mhz with an intensity of 2.0 W/cm².

LITERATURE REVIEW

Anatomy of Multifidus Muscles

The intrinsic musculature of the back is organized into three groups; the superficial, intermediate, and deep muscle groups. The multifidus muscle can be found in the middle layer of the deep intrinsic back musculature. The deep layer is referred to as the transversospinales muscle group and includes semispinalis, located superficial to multifidus, and rotatores which can be found deep to multifidus. The multifidus is a short, obliquely oriented muscle that surrounds the spinal column and provides stabilization during movement. This muscle arises from the posterior sacrum, posterior superior iliac spine, aponeurosis of the erector spinae muscles, sacroiliac ligaments, mammillary process of the lumbar vertebrae, transverse processes of T1-T3, and the articular processes of C4-C7. The muscle then attaches proximally to the spinous processes. Each segment of the muscle spans two to four vertebral levels. The multifidus muscle is
composed of 5 fascial layers and is thickest in the lumbar region. It is innervated by the lateral branch of the posterior rami of spinal nerves.\textsuperscript{3,4} 

**Function of Multifidus**

The multifidus muscle has a number of functions including bilateral back extension, unilateral side bending to the same side, rotation to the opposite side, and most importantly provides stabilization during movement of the spinal column.\textsuperscript{3} Due to the high percentage of Type I muscle fibers, otherwise known as slow twitch fibers, this muscle is designed for sustained contraction and endurance type activities.\textsuperscript{5} The multifidus muscle is a short muscle with a large cross-sectional area which makes the muscle biomechanically ideal for stabilization.\textsuperscript{6} Dysfunction of this muscle creates instability of the affected spinal segment and has been suggested to play a large role in cases of low back pain. In a study conducted by Kjaer and colleagues,\textsuperscript{7} the cross-sectional area of the lumbar multifidus muscles of 412 adults and 442 adolescent subjects were examined. A strong correlation was found between atrophy and fatty infiltrations of the muscle and lower back pain. The results were independent of body mass index (BMI). If untreated, continued dysfunction may lead to increased risk of recurrence episodes of low back pain.\textsuperscript{7}

**Therapeutic Ultrasound**

Ultrasound (US) has been used in the physical therapy setting to treat musculoskeletal conditions for decades. The earliest studies date back to the 1930’s and examined how ultrasound has the ability to increase tissue temperature of superficial and deep structures.\textsuperscript{1} When using US on a continuous duty cycle, it creates a heating effect that heats both skeletal muscle and collagenous structures.\textsuperscript{8} These thermal effects
increase vasodilatation and circulation to the treated area which promote healing by increasing the amount of oxygen and nutrients to the treated area. Thermal US is also known to increase tissue extensibility.\(^9\) There have been several studies to determine the effectiveness of ultrasound as a modality and they have produced conflicting results.\(^9,10\)

Baker et al.\(^{10}\) preformed a systematic review to locate randomized control trials (RCTs) that used ultrasound for treating pain, tissue healing, or musculoskeletal injuries. They found thirty-five RTCs that were published in English between 1975 and 1999. The participants in these studies were randomly assigned to a treatment group or a control group. They filtered out twenty-five of the studies for various reliability concerns including adequate controls, blinding, description of treatment, and sample size. Of the remaining ten RCTs, only two had superior results over the placebo groups. There were a wide range of treatments and intensities with all of these studies and none have been replicated. Thus, more evidence is needed to determine the effectiveness of US on tissue healing.\(^{10}\)

Therapeutic ultrasound is a widely used modality and despite conflicting research regarding the therapeutic effects US may have, many therapists feel that US is a valuable modality. Wong et al.\(^{11}\) randomly selected 457 physical therapists that were registered with the American Physical Therapy Association (APTA) in order to determine the popularity of therapeutic ultrasound as a treatment method. These therapists were also Orthopaedic Certified Specialists (OCS). In the past 10 years these therapists had a minimum of 2,000 hours of direct patient care in orthopedics. Of the randomly selected therapists, 207 participated in the survey in which 71.1% of the respondents claim that...
US is clinically important for treating soft tissue extensibility and 47.0% claim US is important for tissue healing.\textsuperscript{11}

A study performed by Morisette and colleagues\textsuperscript{8} was able to show that therapeutic ultrasound is capable of heating deep tissue structures including the deep musculature of the spine. The study used six healthy subjects to determine if US could be used to heat the zygapophyssal joints in the L4-L5 area. In this study an anesthesiologist placed a thermocouple, a temperature-measuring device, adjacent to the L4-L5 zygapophyssal joint. Ultrasound was applied to an area twice size of the US head for 10 minutes using continuous 1-MHz ultrasound and compared temperatures at intensities of 1.5 W/cm\textsuperscript{2} and 2.0 W/cm\textsuperscript{2}. It was determined that there were greater increases the temperature at the L4-L5 level using 2.0 W/cm\textsuperscript{2}. The temperature was raised by 3 degrees Celsius, which they claim is enough to produce theoretical therapeutic effects.\textsuperscript{8} This study concluded that continuous therapeutic US can heat structures as deep as the zygapophyssal joints in the L4-L5 area when used with an intensity of 2.0 W/cm\textsuperscript{2}. Based on these results, we are able to conclude that therapeutic US can be used to heat the deep tissue structures surrounding the spine including the multifidus muscle.

Therapeutic ultrasound has been used to treat a wide variety of pathologies and dysfunction including cases of low back pain. Ebadi et al.\textsuperscript{12} conducted a study comparing two treatment groups with chronic non-specific lower back pain. Both groups were given a semi-supervised exercise program to complete as well as received a therapeutic US treatment. The experimental group received continuous US treatments with a frequency of 1 MHz and intensity of 1.5 W/cm\textsuperscript{2}. The control group received a placebo US treatment. The group that received continuous US had increased function along with
increased range of motion (ROM) and endurance. This study suggests the idea that the thermal effects of continuous US may benefit those that suffer from lower back pain.

**Instrument Assisted Soft Tissue Mobilization**

Instrument assisted soft tissue mobilization (IASTM) is a form of soft tissue mobilization used to break up scar tissue and adhesions and promote tissue healing. IASTM uses instruments to perform soft tissue mobilization rather than using the therapist’s hands. There are many different brands of instruments that are made from various materials, created in a variety of shapes, and range in price from under $25.00 up to over $3,000.00. Some of the marketed IASTM instruments include the Graston Technique, Edge Mobility System, Ellipse Tools, and HawkGrips. Graston is the leading IASTM technique and therefore the Graston instruments were chosen to be used in this study. Therefore, the research presented in this paper will focus on studies that have used the Graston instruments.

The Graston Technique is an instrument assisted soft tissue mobilization technique. The Graston tool set consists of six stainless steel tools each with different concavities and convexities allowing them to contour to different parts of the body and mobilize structures of various depths. Over the last nineteen years, the prevalence of GT has become more accepted by physical therapists. Currently it is reported that 16,000 clinicians around the world are Graston certified with 1,650 outpatient clinics using the technique in the treatment of patients.

There is little research on the physiological effects of the tools. The developers’ website reports that GT can be used for the following pathologies: cervical and lumbar sprains/strains, carpal tunnel syndrome, lateral and medial epicondylitis, tendinosis,
plantar fasciitis, patellofemoral disorders, fibromyalgia, scar tissue, and trigger finger. The Graston Technique allows for controlled application of friction massage to the targeted treatment area as well as gives the therapist a mechanical advantage greater than provided from manual soft tissue techniques. A better mechanical advantage allows for deeper penetration and possibly better specificity of the treatment. The instruments are used to detect areas of scar tissue, adhesions, and fascial tightness allowing the physical therapist to apply deep pressure strokes to break up the adhesions and increase tissue extensibility. It is theorized that the application of pressure from the tools encourages fibroblast production, which is important in the healing process for collagen production.

The Graston Technique has been used to treat a variety of conditions including sub-acute lumbar compartment syndrome. Hammer and Pfefer presented the results of a case study that used the Graston Technique to treat this diagnosis. Previous standard of care for this condition consisted of surgery used to normalize intramuscular pressures. The patient was a 59 year old man with complaints of severe back pain during flexion activities. He was diagnosed with sub-acute lumbar compartment syndrome and was referred to physical therapy for treatment. The lumbar fascia and fascia overlying the sacrum, hamstrings, and external rotators of the hip were treated using the Graston instruments in combination with a home stretching program. After twelve treatments, the patient was asymptomatic and discharged. The patient was able to actively and passively flex in all directions without complaints of pain or limitations. In this particular case report, the authors found that the GT in combination with stretching was a promising intervention for the treatment of sub-acute lumbar compartment syndrome for this
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Further research needs to be performed in order to determine the effectiveness of this treatment method on a larger population.

The Graston Technique has also been used in the treatment of tendinopathies in multiple regions of the body. Looney et al.\textsuperscript{16} conducted a study to examine the effectiveness of the Graston Technique combined with a home stretching program for treating Plantar Fasciitis. The sample size consisted of ten participants (seven female, three male) all having a chief complaint of heel pain originating at the calcaneal tuberosity, with increased pain during dorsiflexion, and a Lower Extremity Functional Scale score of 65 or less. Outcomes were measured using the Global Rating of Change scale (GRC) and an 11 point pain scale (0=no pain, 10=worst imaginable pain). Participants received a maximum of eight treatments that consisted of 15 minutes of deep pressure Graston Technique over areas where adhesions were found. Participants then performed two repetitions of static stretches, and finally ice was applied to the plantar fascia for 15 to 20 minutes. Results of the study showed that seven of the ten participants had a successful outcome based on the predetermined GRC cutoff scores. There was statistical significance from baseline scores to follow-up scores ($p=.047$).\textsuperscript{16} This study showed that the combination of the Graston Technique and a home stretching program was an effective treatment plan for plantar fasciitis. Although this study showed benefits of this treatment intervention, the study did not use a control group. In addition, the results of the treatment intervention were not compared to the results of standard conservative treatment of plantar fasciitis. Therefore, more research needs to be conducted in order to determine the effectiveness of GT as a treatment method for plantar fasciitis.
Howitt et al.\textsuperscript{17} performed a case study examining the effects of the Graston Technique in the treatment of trigger thumb. Trigger thumb occurs when there is pain and locking in the first digit when moving from flexion to extension. This is caused by the entrapment of the flexor digitorum superficialis or flexor digitorum profundus. In the past, treatment options have consisted of splinting, non-steroidal anti-inflammatory agents, percutaneous injection of corticosteroids, and surgical release. Several of these treatments are invasive and unpleasant for the patient. The case study involved a 42 year old patient who was diagnosed with trigger thumb with diagnostic ultrasound confirmation. The patient complained of moderate thumb pain and was unable to flex and extend the thumb. Pain was reported with both active and passive range of motion. The patient was treated with active release techniques (ART) and the Graston Technique. Treatment consisted of 8 sessions over a span of 4 weeks. After the first treatment, thumb range of motion increased but pain was still present. After the third treatment, pain was minimal and the patient had full range of motion. By the eighth treatment, there was no pain. The patient was contacted two months after discharge and reported no further complications.\textsuperscript{17} The use of GT in conjunction with ART was found to be a successful treatment for adhesion break up and tissue repair for this patient. The outcomes cannot solely be attributed to GT as GT was used in conjunction with other treatment methods. Further research should be performed in order for generalizations to be made.

The Graston Technique has also been used in the treatment of knee arthrofibrosis and quadriceps insufficiency after patellar tendon repair. Black\textsuperscript{18} conducted a case study that examined the efficacy and effectiveness of GT in the treatment of this population. Arthrofibrosis is a surgical complication in which excessive scar tissue builds up causing
limited range of motion, decreased muscle activity, and overall decreased function. Conservative treatment for the condition has not yet been established. The goal of the study was to determine if the Graston Technique used in conjunction with strengthening exercises would be an effective conservative treatment for arthrofibrosis. The patient in this case was a 37 year old male who sustained an injury to his left knee while playing basketball. Following surgery, the patient developed arthrofibrosis and demonstrated range of motion deficits. Treatment consisted of a heat pack applied to the area for 5-7 minutes followed by GT, joint mobilizations, and strengthening exercises. With each visit, the patient demonstrated increased range of motion, and improved function. Pain was completely resolved after 4 treatments and did not return. The patient reported that function of his knee had almost doubled in the month that he received treatment. In this case, treatment consisted of standard physical therapy protocol for the diagnosis other than the choice of the GT. With the use of this intervention, the patient was seen 50-67% less frequently but doubled his functional status. In this particular case report, GT was successful in treating arthrofibrosis of the knee for this patient. However, as in the previous case, GT was used in conjunction with other treatment interventions and the improvements in range of motion cannot solely be attributed to the effects of GT. Further research needs to be performed to determine if this is an effective method for the general population as well as if GT alone effects the healing of arthrofibrosis.

Howitt, et al. performed a study using the Graston Technique to treat a case of a tibialis posterior strain in a triathlete. The patient complained of acute right ankle pain that began three days prior to beginning treatment. Upon examination, the patient was unable to bear weight through the right leg and had limited range of motion in both
plantar flexion and dorsiflexion. The treatment consisted of medical acupuncture, electrical stimulation, GT, ART, and ultrasound. The patient reported gaining full function of the right leg and had no complaints of pain 6 weeks after the initial visit. A follow-up visit was conducted one month later. The patient had returned to his triathlon training and reported no further problems with the injury. They hypothesized that in this case the Graston Technique increased the fibroblast proliferation rate, which partially accounted for the decreased healing time demonstrated in this case.\textsuperscript{19}

Loghmani and Warden\textsuperscript{20} investigated the effects of instrument assisted soft tissue mobilization on tissue healing of the medial collateral ligament in the knee. Rats were used as subjects. A total of 51 animals were used and all underwent surgery to create bilateral medial collateral ligament tears. Seven animals remained untouched and served as the control group. Instrument assisted soft tissue mobilization using the Graston instruments were initiated one week post-operatively. This allowed for the natural inflammatory processes to take place. The experimental group was split into two treatment groups. The first group of rats received 3 treatments a week for 3 weeks. The second group received 3 treatments a week for 10 weeks. Each treatment session lasted 1 minute. The control group was not treated with the Graston instruments. Ligament mechanical testing was performed. Results showed the ligaments that were treated with instrument-assisted cross fiber massage were 43.1% stronger than those that were not. During electron microscopy assessment, these same ligaments were found to have improved collagen fiber formation and orientation. This study found that instrument-assisted cross fiber massage has the potential to accelerate ligament healing and promote organized collagen formation.\textsuperscript{20}
Davidson et al.\textsuperscript{21} performed a study using rats to test if soft tissue mobilization from specifically designed solid instruments to the Achilles tendons could facilitate tendon healing. In this study, there were 4 groups of 5 animals. Group A was the control group and had no treatment, group B had tendinitis, group C had tendinitis and was treated with augmented soft tissue mobilization (ASTM), and group D was treated only with ASTM. Groups B and C were injected with collagenase to induce tendinitis. Groups C and D received four treatments of ASTM lasting 3 minutes each. The ASTM treatments were done 21, 25, 29, and 33 days after they were injected with collagenase. The animals were sacrificed 10 days after their last treatment and their tendons were removed. With a light microscope they were able to verify that group C tendons were misaligned and had the greatest number of fibroblast. This suggest that it is possible that ASTM may facilitate tendon healing in rats but it is difficult purely based on this study to determine if human tendons would react similarly.\textsuperscript{21}

A study done by Burke et al.\textsuperscript{22} used two different manual therapy techniques to treat carpal tunnel syndrome (CTS). Radiographs or physical examination confirmed that the subjects had moderate to severe CTS. The subjects were either treated with Graston Instrument-assisted soft tissue mobilization (GISTM) or soft tissue mobilization manually from the therapists’ hands. To participate in this study the subjects had to have a pain level higher than 33 on a scale of 100 along with 2 other deficits; sleep disturbances caused by CTS, mean symptom-severity and mean functional-status score greater than or equal to 3 out of 5, a positive Tinel’s or Phalen’s sign, strength deficits, sensory touch deficits or limited range of motion. All of the subjects adhered to home exercises for stretching and strengthening and averaged a total of ten treatments with one
of the modalities. The 22 subjects from both groups in this study increased their wrist range of motion, strength, and nerve conduction latencies after completing their treatment. Both techniques produced similar results and concluded that more test need to be done with larger sample sizes to determine if soft tissue mobilization is a feasible alternative to invasive techniques.²²

Research has also been performed to determine the effect that GT has on treatment time and therapist fatigue. As previously mentioned, the developers of the Graston tools advertise that the tools decrease treatment time as well as decrease the stress placed on the therapist during treatment. The study performed by Black¹⁸ found that the Graston Technique decreased the necessary treatment time for arthrofibrosis. Many other studies using the GT have also produced similar results in showing decreased treatment time when using the Graston instruments. Hayes et al.²³ performed a study comparing two different instrument assisted soft tissue mobilization tools and their effects on therapist discomfort and fatigue to treatment time. The instruments that were compared were the Graston tools and the metal end of a reflex hammer. The sample included 13 therapists from a metropolitan hospital that treated 23 outpatient plantar fasciitis patients. The patients were randomized and received treatment from either the Graston instruments or the reflex hammer. After each treatment session, the therapists were asked to rate their discomfort and fatigue levels using a visual analog scale 0-10 (0-indicated no discomfort/fatigue, 10- indicated extreme discomfort and fatigue). Location of discomfort in the upper extremities was also noted. Results showed that therapists reported less discomfort and fatigue when using Graston tools compared to the reflex
hammer. This study showed that GT has potential benefits for therapists by decreasing the discomfort and fatigue experienced when performing instrument assisted soft tissue.

Research has been conducted with the purpose of attempting to determine the effect of GT on various conditions. Although many of these studies have found positive results, there are many weaknesses to the research that has been discussed. Many of the research studies are case studies and therefore the results cannot be generalized to a larger population. Further research needs to be conducted using a larger sample in order to make generalizations about the effectiveness of the Graston Technique as a treatment for a multitude of conditions. Another weakness of the current research is that multiple research studies used GT in conjunction with other treatment interventions and therefore the results of the study cannot solely be attributed to GT. There is little to no research on the specific effects that GT has on muscle size and contractibility and therefore this research study will provide new information regarding these effects.

**Ultrasound Imaging**

Ultrasound Imaging (USI) is growing in popularity with physical therapists for the measurement of muscle characteristics. Grayscale USI provides two types of information: reflective properties that indicate the type of tissue being viewed and the architectural properties of the tissue such as size and shape. It is both accurate and reliable when measuring muscle characteristics such as width, thickness and cross-sectional areas. This has made it a valuable tool for measuring muscle changes. According to Stokes et al., the multifidus muscles are the most widely studied paraspinal muscles. Rehabilitative ultrasound imaging (RUSI) is used to observe dynamic muscle contractions and provide real-time biofeedback.
Schrank and colleagues\textsuperscript{25} performed a study with three 2\textsuperscript{nd} year DPT students that were novice raters and one experienced rater. The experienced rater had seventeen years of orthopedic physical therapy experience, twenty-three hours of continuing education in RUSI, and three years’ experience assessing muscles with USI. The novice raters had 2 hours of basic education in USI and 4 hours of practice time along with small group practice time. Their studies focused on the transverse abdominis and the lumbar multifidus. They measured the thickness of the multifidus at the L2-3 and L4-5 zygapophyseal joints in the sagittal plane using the US machine. Measurements were taken three times at both locations on twenty subjects. The inter-rater reliability of the novice was greater at the L4-5 level with an intraclass correlation coefficient (ICC) of 0.905 and a standard error of measurement SEM of 0.145 cm. The inter-rater reliability was slightly lower at the L2-3 level with an ICC of 0.706 and an SEM of 0.253 cm.\textsuperscript{25}

Wallwork et al.\textsuperscript{26} conducted a similar study with one novice and one experienced operator. The novice had 3 hours of education in US imaging techniques and 3 hours of observing the experienced operator. The novice measured five subjects prior to the study. There were ten subjects in this study. The multifidus muscle at the L2-3 and L4-5 segments were measured in the parasagittal plane. There was a high level of inter-rater and intra-rater reliability with greater amount at the L4-5 level. The inter-rater reliability, based on a single measurement per rater, at the L2-3 had an ICC of 0.85 with a SEM of 0.13 cm. The ICC at the L4-5 level was 0.87 with a SEM of 0.10 cm.\textsuperscript{26}

These studies have demonstrated that with 3-4 hours of training using the ultrasound imaging machine, a novice operator is capable of taking images of the lumbar multifidus muscles with high intra-rater reliability. Therefore, for the purpose of this
research study, a single 3rd year physical therapy student will receive 5 hours of training with guidance from an experienced operator in order to ensure high intra-rater reliability.

**Theoretical Framework**

US and the Graston Technique have been used in the treatment of multiple musculoskeletal conditions. Many of the Graston Technique studies have found positive results, but their quality of evidence is low. The developers of the GT report their tools stimulate fibroblast proliferation, which leads to increased collagen synthesis, an important part of the healing process.\(^{18}\) Although research has started to determine the effects of the Graston Technique on musculoskeletal conditions, its' effect on muscle contractibility have not yet been determined. Studies using both these modalities suggest improved function and ROM possibly due to fascial tightness. The study by Ebadi et al.\(^ {12}\) used US to treat low back pain allowing the treatment group to increase their function, ROM and endurance.\(^ {12}\) These results are similar to treating trigger thumb and sub-acute lumbar compartment syndrome with GT.\(^ {15,17}\) Even though the study performed by Wong et al.\(^ {11}\) wasn’t able to provide physical evidence that US is a creditable modality, many of the experienced therapist felt that US is important for tissue extensibility. Cameron\(^ {1}\) states that soft tissue increases its extensibility when heated. It has also been shown that both of these modalities increase blood flow increasing the temperature of the treatment area.\(^ {1,12}\) Increased blood flow leads to increased amounts of available oxygen and nutrients to the tissue, which aids in the healing process and could also benefit muscle contractibility.\(^ {1,2,12}\) In theory, these modalities could increase contractibility of the multifidus muscles and reduce self-limiting behaviors leading to atrophy and fatty infiltrations. Wallwork et al.\(^ {27}\) stated that patients with multifidus muscle atrophy were unable to voluntarily contract at
that level. For this reason healthy subjects were used to determine if these modalities produce any immediate changes to the CSA.

**METHODS**

The study was a quasi-experimental design in which healthy individuals were recruited from the Florida Gulf Coast University student population were treated with therapeutic ultrasound and GT on opposite sides of their lumbar spine at the L5 multifidus. Prior to treatment, images of the muscles were collected using the GE LOGIQ e diagnostic ultrasound machine. Treatment was provided and post-treatment images were collected. The independent variable for this study was the treatment type, either GT or therapeutic US. The dependent variable for this study was the difference between the cross-sectional area of the multifidus muscles at the L5 level prior to and following treatment.

**Participants**

This independent research study was approved by the Florida Gulf Coast University Institutional Review Board. Twenty-Five participants were recruited using recruitment emails and convenience sampling. Students were recruited from the Physical Therapy & Human performance Department. Participants included 11 male and 14 female subjects between the ages of 18-45 years. Exclusion criteria for participants included: history of previous or current episodes of LBP, previous spinal surgeries, and must not have been diagnosed with any spinal deformities such as scoliosis or spina bifida, neuromuscular conditions, joint disease, malignant tissue, or current pregnancy. Testing was performed on the Florida Gulf Coast University campus in the Physical
Therapy lab. The following table (Table 1) represents the gender and age distribution of the research participants.

Although 25 participants were recruited, some of the images collected were not able to be analyzed in the results because the full image was not seen on the screen. The number of subjects (N) that were used to analyze each of the variables are provided within the results tables.

**Table 1. Participant Demographics**

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</table>

**Procedure**

Once participants arrived to the data collection site, each participant was asked to complete a medical health questionnaire as well an informed consent form that was approved by the Institutional Review Board. The medical health questionnaire included questions regarding their gender, age, and past medical history questions about previous and current episodes of low back pain, spinal surgeries, spinal deformities, and malignancies. Once we received both completed documents with participant and witness signatures, the participants were asked to lie prone on a treatment table.

The participants were positioned with two pillows underneath their ASISs and an inclinometer was used to ensure that their lumbar spine was in no more than 5 degrees lumber flexion. Once this was confirmed, 3lb ankle weights were placed on each ankle at
the level of the medial and lateral malleolus. An adjustable table was positioned 4 inches over the participants' feet in order to standardize the distance that each participant could raise their leg in order to contract the targeted lumbar multifidus. This distance was confirmed with a tape measure. The participant was asked to lift his or her shirt to expose the lumbar region to be treated and towels were used to drape the participants in order to protect their clothing from the ultrasound gel. Finally, the participant was asked if they had any allergies to topical agents such as massage lotion or ultrasound gel.

Once the participant was positioned correctly, the L5 spinous process was palpated and marked with a skin pen. Ultrasound gel was applied and a 5-MHz curvilinear transducer head was used to locate the left and right lumbar multifidi on the diagnostic ultrasound machine. The location of the superior aspect of the transducer was marked bilaterally to improve accuracy of taking the images. Three images of the multifidi were taken in a relaxed state bilaterally. The participant was then asked to lift his or her ipsilateral leg the designated 4 inches off of the table in order to contract the multifidus and an image was taken. The participant was then asked to relax and lower his or her leg. This was repeated three times bilaterally. A total of 12 images pre-treatment images were collected. All diagnostic ultrasound images were collected by a single trained physical therapy student (C. Caldwell). Five hours of training using the GE LOGIQ e diagnostic ultrasound machine were completed prior to data collection.

Following the collection of the pre-treatment images, the intervention was initiated. The participant was educated about the therapeutic ultrasound and instructed that they may feel slight warmth in the treatment area and if at any time they felt any pain or unexpected sensations to alert the researcher and treatment would be stopped.
Therapeutic ultrasound was performed on the right side of the lumbar spine at the L5 region for 10 minutes using continuous 1-MHz ultrasound at an intensity of 2.0 W/cm². According to Morisette et al, these parameters were shown to produce a greater thermal effect. All US treatments were performed by a third year physical therapy student (M. Holman) with supervision from a faculty member. During the final 2 minutes of the ultrasound treatment, GT was applied to the left side of the L5 multifidus region. Graston treatment was provided by Brian Bochette, PT, DPT, CSCS, a level 2 certified Graston IASTM provider. Post-treatment images were taken immediately following the completion of the intervention. These images were taken in the same manner as the pre-treatment images. A total of 12 post-treatment images were collected consisting of 3 relaxed and 3 contracted images of the left and right L5 multifidus.

During the data collection process, multifidus height and width measurements were recorded on a data collection sheet and were then entered into a Microsoft Excel spreadsheet to be analyzed. Following the completion of data collection, the images were reviewed by the same student who took the images and the cross sectional area and circumference of the multifidus muscle in each image was calculated. This was done by using the caliper function on the diagnostic ultrasound machine in which the data collector traces the muscle on the screen and the cross sectional area is calculated by the machine. The cross sectional area measurements were then also entered into the Microsoft Excel spreadsheet for data analysis.

Figure 1 shows the application of IASTM using the Graston Technique to the right side of the lumbar spine at the L5 level as well as the application of therapeutic
ultrasound to the left L5 multifidus region. Figure 2 demonstrates patient positioning during the collection of the diagnostic ultrasound images.

Data Analysis

Statistical analysis was performed using the IBM SPSS Statistics (version 22) software. The cross sectional area measurements that were collected from the GE LOGIQ e diagnostic ultrasound machine as well as the height and width measurements of all images were manually entered into Microsoft Excel and then imported into SPSS. Other data included on the Microsoft Excel spreadsheet included gender and age of the participants, and the calculated difference between the pre-treatment and post-treatment cross sectional areas of both the left and the right L5 multifidus muscles.

Reliability tests were conducted in order to determine the intraclass correlation coefficient (ICC). An intraclass correlation coefficient (ICC) is a measure of reliability among variables within groups. In this study, we calculated the ICC in order to determine the intra-rater repeated measure reliability when measuring the height, width, circumference, and cross sectional area of the lumbar multifidus.
In order to evaluate research question one, paired t-tests were conducted comparing the average measures obtained for both relaxed and contracted pre-treatment cross sectional areas with the average measures obtained for both relaxed and contracted post-treatment cross-sectional areas of the left L5 lumbar multifidus in order to determine the values for t, df, and p. For the purposes of this study, the alpha level was set at 0.05. Other paired t-tests that were run included the comparison of the calculated average height, width, and circumference for both relaxed and contracted pretreatment images on the left with relaxed and contracted calculated averages of height, width, and circumference measures of the left L5 lumbar multifidus in order to obtain more information about the data.

In order to evaluate research question two, paired t-tests were conducted comparing the average measures obtained for both relaxed and contracted pre-treatment cross sectional areas with the average measures obtained for both relaxed and contracted post-treatment cross-sectional areas of the right L5 lumbar multifidus in order to determine the values for t, df, and p. Other paired t-tests that were run included the comparison of the calculated average height, width, and circumference for both relaxed and contracted pretreatment images on the right with relaxed and contracted calculated averages of height, width, and circumference measures of the right L5 lumbar multifidus in order to obtain more information about the data.

RESULTS

The single measures ICC is an index for reliability of a single rater, which in this case was the diagnostic ultrasound operator, were examined. An ICC of >0.7 and greater is an indication of high reliability. The following tables (Table 2-5) represent the results.
of the ICC for each of the measures in this study. We examined the ICC of the pre-treatment and post-treatment height, width, circumference, and cross sectional area of the left and right multifidus.

### Table 2. ICC-Height (N=25)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>PreRlx US Height</td>
<td>.910</td>
<td>0.835</td>
</tr>
<tr>
<td>PostRlx US Height</td>
<td>.927</td>
<td>0.865</td>
</tr>
<tr>
<td>PreCont US Height</td>
<td>.952</td>
<td>0.909</td>
</tr>
<tr>
<td>PostCont US Height</td>
<td>.894</td>
<td>0.806</td>
</tr>
<tr>
<td>PreRlx Inst Height</td>
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</tr>
<tr>
<td>PostRlx Inst Height</td>
<td>.931</td>
<td>0.872</td>
</tr>
<tr>
<td>PreCont Inst Height</td>
<td>.936</td>
<td>0.88</td>
</tr>
<tr>
<td>PostCont Inst Height</td>
<td>.902</td>
<td>0.82</td>
</tr>
</tbody>
</table>

PreRlx = Pretreatment Relaxed  
PreCont = Pretreatment Contracted  
PostRlx = Post-Treatment Relaxed  
PostCont = Post-Treatment Contracted  
Inst = Graston Technique instrument assisted  
US = Therapeutic Ultrasound

### Table 3. ICC-Width (N=25)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>PreRlx US Width</td>
<td>.896</td>
<td>0.81</td>
</tr>
<tr>
<td>PostRlx US Width</td>
<td>.870</td>
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<td>PreCont US Width</td>
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<tr>
<td>PostCont US Width</td>
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<td>PreRlx Inst Width</td>
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<td>PostRlx Inst Width</td>
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<td>0.797</td>
</tr>
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<td>PreCont Inst Width</td>
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<td>0.761</td>
</tr>
<tr>
<td>PostCont Inst Width</td>
<td>.901</td>
<td>0.82</td>
</tr>
</tbody>
</table>

PreRlx = Pretreatment Relaxed  
PreCont = Pretreatment Contracted  
PostRlx = Post-Treatment Relaxed  
PostCont = Post-Treatment Contracted  
Inst = Graston Technique instrument assisted  
US = Therapeutic Ultrasound

CrossSect = Cross sectional area in cm²  
Circum = Circumference
Table 4. ICC - Cross Sectional Area (N=20)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td>Lower Bound</td>
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<tr>
<td>PreRlx US CrossSec</td>
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<td>PostRlx US CrossSec</td>
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</tr>
<tr>
<td>PreCont US CrossSec</td>
<td>.974</td>
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<tr>
<td>PostCont US CrossSec</td>
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</tr>
<tr>
<td>PreRlx Inst CrossSec</td>
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<tr>
<td>PostRlx Inst CrossSec</td>
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<td>0.926</td>
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<td>PostCont Inst CrossSec</td>
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<td>0.925</td>
</tr>
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</table>

PreRlx= Pretreatment Relaxed
PreCont= Pretreatment Contracted
PostRlx= Post-Treatment Relaxed
PostCont= Post-Treatment Contracted
Inst- Graston Technique instrument assisted

Table 5. ICC - Circumference (N=20)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
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<tr>
<td>PreRlx US Circum</td>
<td>.961</td>
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</tr>
<tr>
<td>PostRlx US Circum</td>
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<tr>
<td>PreCont US Circum</td>
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<td>PostCont US Circum</td>
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<td>PreRlx Inst Circum</td>
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<td>PostRlx Inst Circum</td>
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<td>PreCont Inst Circum</td>
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<tr>
<td>PostCont Inst Circum</td>
<td>.959</td>
<td>0.905</td>
</tr>
</tbody>
</table>

PreRlx= Pretreatment Relaxed
PreCont= Pretreatment Contracted
PostRlx= Post-Treatment Relaxed
PostCont= Post-Treatment Contracted
Inst- Graston Technique instrument assisted

The following table (Table 6) represents the calculated averages of all of the collected data. Due to the difficulties determining the borders of the multifidus muscles for 16 of
the 32 measurements, portions of the measurements of the circumference and cross sectional area for some of the participants were excluded the averages and identified in the number (N) of participants in table 6.

**Table 6. Descriptive Statistics - Height**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>PreRelx US Height</td>
<td>2.9888</td>
<td>25</td>
<td>0.81231</td>
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</tr>
<tr>
<td>PostRelx US Height</td>
<td>2.99</td>
<td>25</td>
<td>0.75642</td>
<td>0.15128</td>
</tr>
<tr>
<td>PreCont US Height</td>
<td>3.496</td>
<td>25</td>
<td>0.77107</td>
<td>0.15421</td>
</tr>
<tr>
<td>PostCont US Height</td>
<td>3.4588</td>
<td>25</td>
<td>0.7655</td>
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<tr>
<td>PreRelx Inst Height</td>
<td>2.87</td>
<td>25</td>
<td>0.67834</td>
<td>0.13567</td>
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<tr>
<td>PostRelx Inst Height</td>
<td>2.8232</td>
<td>25</td>
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</tr>
<tr>
<td>PreCont Inst Height</td>
<td>3.4492</td>
<td>25</td>
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<td>PostCont Inst Height</td>
<td>3.4416</td>
<td>25</td>
<td>0.70702</td>
<td>0.1414</td>
</tr>
</tbody>
</table>

PreRelx= Pretreatment Relaxed  
PreCont= Pretreatment Contracted  
PostRelx= Post-Treatment Relaxed  
PostCont= Post-Treatment Contracted  
Inst= Graston Technique instrument assisted  
Soft Tissue Mobilization  
CrossSect= Cross sectional area in cm$^2$  
Circum= Circumference  
US= Therapeutic Ultrasound

**Table 7. Descriptive Statistics - Width**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
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<td>PostRelx US Width</td>
<td>6.6028</td>
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<td>PreCont US Width</td>
<td>6.0116</td>
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<td>0.89482</td>
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</tr>
<tr>
<td>PostCont US Width</td>
<td>6.1104</td>
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<td>1.06943</td>
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<tr>
<td>PreRelx Inst Width</td>
<td>6.7688</td>
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<tr>
<td>PostRelx Inst Width</td>
<td>6.8108</td>
<td>25</td>
<td>0.86241</td>
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<tr>
<td>PreCont Inst Width</td>
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<tr>
<td>PostCont Inst Width</td>
<td>6.322</td>
<td>25</td>
<td>0.92158</td>
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</table>

PreRelx= Pretreatment Relaxed  
PreCont= Pretreatment Contracted  
PostRelx= Post-Treatment Relaxed  
PostCont= Post-Treatment Contracted  
Inst= Graston Technique instrument assisted  
Soft Tissue Mobilization  
CrossSect= Cross sectional area in cm$^2$  
Circum= Circumference  
US= Therapeutic Ultrasound
### Table 8. Descriptive Statistics - Cross Sectional Area

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>PreRlx US CrossSect</td>
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<td>19</td>
<td>5.13852</td>
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<tr>
<td>PostRlx US CrossSect</td>
<td>18.2968</td>
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<tr>
<td>PreCont US CrossSect</td>
<td>18.8356</td>
<td>18</td>
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</tr>
<tr>
<td>PostCont US CrossSect</td>
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<td>6.25356</td>
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<tr>
<td>PreRlx Inst CrossSect</td>
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<td>PostRlx Inst CrossSect</td>
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<td>PreCont Inst CrossSect</td>
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<tr>
<td>PostCont Inst CrossSect</td>
<td>19.589</td>
<td>19</td>
<td>5.38201</td>
<td>1.23472</td>
</tr>
</tbody>
</table>

PreRlx= Pretreatment Relaxed  
PreCont= Pretreatment Contracted  
PostRlx= Post-Treatment Relaxed  
PostCont= Post-Treatment Contracted  
Inst= Graston Technique instrument assisted  
US- Therapeutic Ultrasound  
Graston Technique instrument assisted  
CrossSect= Cross sectional area in cm²  
Circum= Circumference  
soft tissue mobilization

### Table 9. Descriptive Statistics - Circumference

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>PreRlx US Circum</td>
<td>18.43</td>
<td>19</td>
<td>2.45792</td>
<td>0.56388</td>
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<tr>
<td>PostRlx US Circum</td>
<td>18.2974</td>
<td>19</td>
<td>2.45341</td>
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<tr>
<td>PreCont US Circum</td>
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<td>PostCont US Circum</td>
<td>17.8906</td>
<td>18</td>
<td>2.44632</td>
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<tr>
<td>PreRlx Inst Circum</td>
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<td>2.35778</td>
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<tr>
<td>PostRlx Inst Circum</td>
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</tr>
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<td>PreCont Inst Circum</td>
<td>17.9321</td>
<td>19</td>
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<td>PostCont Inst Circum</td>
<td>18.3084</td>
<td>19</td>
<td>2.10528</td>
<td>0.48298</td>
</tr>
</tbody>
</table>

PreRlx= Pretreatment Relaxed  
PreCont= Pretreatment Contracted  
PostRlx= Post-Treatment Relaxed  
PostCont= Post-Treatment Contracted  
Inst= Graston Technique instrument assisted  
US- Therapeutic Ultrasound  
Graston Technique instrument assisted  
CrossSect= Cross sectional area in cm²  
Circum= Circumference  
soft tissue mobilization
The left L5 multifidus was treated with two minutes of the Graston Technique. Pre-treatment measures and post-treatment measures were compared. The results of the paired t-test evaluating research question one found that there was no statistical difference \((t= -.063, \text{df}= 17, p=0.951)\) between pretreatment average relaxed muscle state cross sectional area on the left L5 multifidus and post-treatment average relaxed muscle state cross sectional area measure. No statistical significance \((t= -.759, \text{df}=18, p=0.457)\) was found when comparing pre-treatment average contracted muscle state cross sectional area and post-treatment average contracted muscle state cross sectional area of the left L5 multifidus. The results of the paired t-tests analyzing the significance of the calculated difference between the left pre-treatment average height, width, and circumference and post-treatment left average height, width, and circumference measures. No statistical significance was found for any of the calculated difference measures. The data from all paired t-tests are presented in Table 10 located in Appendix A.

The right L5 multifidus was treated with 10 minutes of therapeutic US using continuous 1-MHz ultrasound at an intensity of 2.0 W/cm². Pre-treatment measures and post-treatment measures were compared. The results of the paired t-test evaluating research question 2 found that there was no statistical difference \((t= -.486, \text{df}= 18, p=0.633)\) between pretreatment average relaxed muscle state cross sectional area on the right L5 multifidus and post-treatment average relaxed muscle state cross sectional area measure. No statistical significance \((t= -1.280, \text{df}=17, p=0.218)\) was found when comparing pre-treatment average contracted muscle state cross sectional area and post-treatment average contracted muscle state cross sectional area of the right L5 multifidus. The results of the paired t-tests analyzing the significance of the calculated difference...
Effect of US and Graston on Muscle Contraction

between the right pre-treatment average height, width, and circumference and post-treatment right average height, width, and circumference measures. No statistical significance was found for any of the calculated difference measures. The data from all paired t-tests are presented in Table 11 in Appendix B.

DISCUSSION

Various studies have been conducted to determine the inter-rater and intra-rater reliability of novice diagnostic ultrasound operators and their ability to measure the height of the lumbar multifidus muscle. 25,26 Studies conducted by Shrank et al. and Wallwork et al. found that with minimal training varying from 6-7 hours, inter-rater and intra-rater reliability was found to be high with ICC values ranging from 0.85-0.905. In both of these studies, reliability was determined based on the novice operator’s ability to measure the thickness or height of the lumbar multifidus muscle at the L2-3 and L4-5 spinal segments.25, 26 To our knowledge, this is the first study that has analyzed the intra-rater reliability of a novice operator measuring not only the height of the lumbar multifidus, but also the width, circumference, and cross sectional area. Results of this study found that a novice operator with 2 hours of formal training and 3 hours of hands on practice can reliably measure the height, width, circumference, and cross sectional area with an ICC ranging from 0.810 to 0.974.

The results of this study are clinically significant for a variety of reasons and are applicable to the clinical setting. When compared to previous studies, being able to reliably measure the height, width, circumference, and cross sectional area provides greater information about the size and contractibility of the muscle compared to measuring only the height of the muscle. Diagnostic ultrasound machines are becoming
increasingly affordable and therefore are becoming more prevalent within the clinic. Diagnostic ultrasound machines can be used to diagnose and monitor various musculoskeletal conditions as well as assess muscle contraction and muscle size. The results of this study along with others have shown that with minimal training, physical therapists can reliably use measure the size of the lumbar multifidus at the L4 spinal segment during the relaxed and contracted states. Further research should be conducted to determine the inter-rater and intra-rater reliability of measuring the size of various muscles throughout the body.

Instrument assisted soft tissue mobilization has been used to treat a variety of musculoskeletal conditions. As discussed previously, it is believed that the tools work by allowing therapists to detect areas of fascial restrictions and scar tissue. Once an area is detected, the area is treated with deep pressure designed to mobilize the soft tissue, break up adhesions, and cause micro trauma to the region in order to promote a local inflammatory response. The local inflammatory response involves increasing the blood flow to the muscle in order to promote healing but also would increases the cross sectional area of the muscle.

Current available research includes various case studies as well as research studies using non-human subjects. The case studies used the Graston Technique to treat a variety of conditions ranging from tendinopathies to trigger thumb, and arthrofibrosis. In each case, Graston was used between 4-12 sessions and was used in conjunction with other interventions including stretching, strengthening, and modalities. Not one of the presented case studies used Graston as the sole intervention and therefore improvements in patient symptoms could not solely be attributed to the effects of the technique. These
studies used outcome measures including pain, functional scales and range of motion, rather than analyzing the physiological effects that IASTM has on soft tissue structures. Therefore, despite beneficial results, these studies did not determine the mechanism in which this technique works. The purpose of this study was to determine the immediate physiological effects that IASTM has on muscle contractibility and size.

Research studies that have been conducted using rat subjects have made promising gains in determining the effects of IASTM at the cellular level. In the study by Loghmani and Warden\textsuperscript{20}, 51 rats underwent surgery to create bilateral medial collateral ligament tears. Seven rats served as the control group and remained untouched; however the remaining subjects all received IASTM using the Graston Technique beginning 1 week post-operatively. Within the treatment group, 1 group of rats was treated with the technique for 3 weeks and the second group received treatment for 10 weeks. Ligaments were examined microscopically and those treated with Graston were found to have improved collagen formation and orientation and were 43.1% stronger than those that did not receive treatment. This study was able to determine that using Graston during the ligament healing process led to improved collagen formation and orientation. It is important to remember that these results were found microscopically and were not visibly to the human eye.

Another animal study that was conducted in order to determine the effects of IASTM at the cellular level was a study performed by Davidson et al.\textsuperscript{21}. The study used rats to determine the effects of IASTM on tendon healing following tendinitis. Tendons were examined microscopically and the study determined that tendons treated with IASTM had better aligned collagen orientation and decreased fibroblastic activity when compared
to tendons that were not treated with the technique. This indicated that tendons healed faster when treated with IASTM. Again, these results were found microscopically and were not visible to the human eye.

Current research is not available on the direct effects that IASTM has on muscle contractility and size. The purpose of this study was to determine these immediate effects. However, the results of this study found no significant changes in the cross sectional area of the L5 multifidus muscles while the muscle is both relaxed and contracted before and immediately following IASTM using the Graston Technique. There are multiple possible explanations as to why no statistical difference was found, the first being simply that IASTM may not have direct effects on muscle contractility and size and therefore no significant changes observed. Another explanation for these results is that changes to the muscle at the cellular level may not be able to be seen with the human eye and may require a microscope to determine the physiological effects of the interventions similar to the rat studies discussed. Further research would need to be conducted in order to determine if microscopic changes are occurring within the muscle.

For the purposes of this study, only healthy subjects with no prior episodes of back pain, surgeries, or diagnosed deformities were included in the sample. Physiological changes may not be significant in this population as compared to participants with history of low back dysfunction. Significant physiological changes may also not occur when a peak contraction of the multifidus is not achieved. For purposes of standardization, a 3lb ankle weight was used for all participants during unilateral leg lifts in order to contract the multifidus. For many participants, 3lbs may not have been sufficient to achieve a maximal contraction of the multifidus. It is suggested in further research that the chosen
weight be individualized for each participant. This would be achieved by determining the participants’ 1 or 10 rep max and using the appropriate weight. It is also suggested that research be conducted on individuals with multifidus pathology in order to determine if there are significant immediate physiological changes in regards to muscle contractibility and size.

Therapeutic ultrasound is a widely used thermal modality with research studies that date back to the 1930’s. It works by using sound waves that are generated by vibrating crystals within the ultrasound head which are transmitted through the skin and have a local heating effect to the surrounding soft tissues. Ultrasound has also been found to cause tissue relaxation, increase local blood flow, and break down scar tissue and fascial adhesions. Similar to IASTM, increased blood flow to the treated area is believed to increase the cross sectional area of the muscle.

Morisette and colleagues were able to demonstrate that continuous therapeutic ultrasound is capable of heating deep tissue structures including the deep musculature and zygapophysial joints in the L4-L5 region. The study found a 3 degree Celsius change in temperature which was determined to be significant indicating that the increase in temperature will lead to an increase in the blood flow to the region. However, the results of this study found no significant changes in the cross sectional area of the L5 multifidus muscles while the muscle is both relaxed and contracted before and immediately following therapeutic ultrasound.

Similar explanations to those discussed about IASTM can be used to explain these outcomes. Therapeutic ultrasound may not have a direct impact on muscle contractibility and size and therefore would explain why no significant changes were observed. It is also
possible that physiological changes may not be detected by the human eye and would require a microscope to visualize. Other explanations include the use of healthy subjects with no history of low back pain, pathology, or spinal deformities. Therapeutic ultrasound may have a great impact on those individuals with multifidus pathology. Finally, as discussed previously a significant change may not occur without a peak contraction of the multifidus which is likely to not have been achieved for all individuals with a 3lb ankle weight.

There are a few other potential limitations to this study. An additional factor that needs to be considered is that this was only a single treatment session. Other studies using both of these modalities describe results after multiple treatments in conjunction with other treatments such as stretching, strengthening, and exercises performed at home. The study methodology accounted for the learning effect by having the patient perform three separate muscle contractions and taking the average height, width, circumference, and cross sectional area for analysis.

In this study, diagnostic ultrasound images were taken immediately following treatment. The purpose of the study was to determine the immediate physiological effects that therapeutic ultrasound and the IASTM Technique have on muscle contraction of the L5 multifidus in healthy individuals as measured by diagnostic ultrasound imaging. The study found that there are no significant differences in the immediate effects of both therapeutic ultrasound and IASTM on the cross sectional area of the lumbar multifidus muscles, however results might be different if images were taken at various increments of time following treatment such as 5, 10, and 15 minutes following. This is another
suggestion for further research in order to determine if changes in cross-sectional area are more significant with increased time following treatment.

All of these limitations should be addressed in future research studies. It is suggested that further research be conducted to determine the effect that therapeutic ultrasound and IASTM have on muscle contraction of the lumbar multifidus after various increments of time as well as following multiple treatment sessions.

CONCLUSION

Although the results of this study found no significant difference in the immediate effects of both therapeutic ultrasound and IASTM on the cross-sectional area of the lumbar multifidus muscles while relaxed and contracted as measured using diagnostic ultrasound, this study was able to show that a novice diagnostic ultrasound operator with minimal training can reliably measure the height, width, circumference and cross-sectional area of the lumbar multifidus at the L4 spinal level. This is important because with minimal training, novice operators can now reliably use diagnostic ultrasound within the clinical setting to measure and monitor changes in multifidus size and contractibility. Further research is recommended to examine the long-term physiological effects of these treatment interventions on the lumbar multifidus muscles after various increments of time following treatment as well as the effects after multiple treatment sessions.
References


### Appendix A: Table 10: Pre and Post Treatment Differences - IASTM

Table 10: Pre and Post Treatment Differences - IASTM \( (t, \text{df}, p) \)

<table>
<thead>
<tr>
<th>Paired T-Test Variables</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% CI of the difference Lower</th>
<th>95% CI of the difference Upper</th>
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<th>df</th>
<th>Sig (t-tailed)</th>
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### Appendix B: Table 11: Pre and Post Treatment Differences - US

**Table 11: Pre and Post Treatment Differences - Therapeutic US (t, df, p)**

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<th>Std. Error Mean</th>
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<th>95% CI of the difference Upper</th>
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<th>df</th>
<th>Sig (t-tailed)</th>
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