Spring 5-1-2014

Effects of Light Brushing on Clinical Pain Intensity and Experimental Pain Sensitivity in Fibromyalgia Patients

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A Thesis

Presented to

The College of Graduate and Professional Studies

Department of Applied Medicine and Rehabilitation

Indiana State University

Terre Haute, Indiana

In Partial Fulfillment

of the Requirements for the Degree

Masters of Science

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by

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May 2014

Keywords: Graston, Pain, Fibromyalgia, Light Brushing, IASTM

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CHAPTER 1

INTRODUCTION

Millions suffer from acute or chronic pain every year and the effects of pain place a tremendous strain on our country in health care costs, rehabilitation and lost worker productivity.[1] Pain also places an emotional and financial burden on patients as well as their families. Pain affects more Americans than diabetes, heart disease and cancer combined.[1] More than 25% of Americans 20 years of age and older, or an estimated 76.5 million Americans, reported that they have had pain that persisted for more than 24 hours.[2] Among the symptoms causing chronic pain, Fibromyalgia syndrome is one of the leading causes of labor loss and expenditures of medication and therapy.[3]

Many different modalities and techniques have been employed in a variety of settings in attempts to decrease pain, such as manual therapy, heat, ice and electrical stimulation.[1] Manual therapy techniques have often been utilized to help decrease pain caused by chronic musculoskeletal conditions. Studies have shown that the use of manual therapy is effective in decreasing pain and disability.[4,5] Manual therapy commonly includes massage therapy, joint mobilization, myofascial release and active release technique among other forms. These techniques, especially when performed often, can become fatiguing and difficult on the clinician's hands. To overcome this obstacle, instrument assisted soft tissue mobilization techniques (IASTM) have become more popular, including Gua Sha and Graston Technique.[6]

The Graston Technique is an instrument-assisted soft tissue mobilization technique based on the concepts of manual therapy and cross friction massage.[7] The "light brushing" stroke is proposed to desensitize the treatment area prior to more aggressive stages of the protocol.[8] Methods such as manual therapy and massage have been proven to decrease pain and disability in injured subjects.[4,5,9-11] The Graston Technique may be an additional intervention that clinicians could use in the treatment of pain and soft tissue conditions.

Donahue, Docherty and Schrader conducted a study at Indiana University to determine the effect of GT's "light brushing" stroke on Pressure Pain Threshold (PPT) measurement in healthy subjects.[10] PPT was tested before and after all 30 participants received a 4-minute "light brushing" only treatment. No significant difference was identified in PPT values and they concluded that GT's light brushing stroke was not able to desensitize either test site in a way that had a significant effect on PPT values.[10] The main limitation is they used healthy participants with no pain.

The purpose of this study is to determine the effect that GT's light brushing stroke has on the central processing of pain. Experimental pain measurements will be taken to determine pain related changes at both the local and central level. Heat temporal summation will be measured to determine the effects on the central pain modulatory system.

Research Hypothesis

The light brushing Graston Technique decreases clinical pain intensity and will affect central pain processing in subjects with Fibromyalgia compared with healthy controls.

The hypothesis was tested by addressing 2 specific aims:

1. To determine if clinical pain intensity (measured by Brief Pain Inventory) changes between pre and post light brushing Graston technique in patients with Fibromyalgia compared with healthy controls.
2. To determine if central pain processing (measured by temporal summation, cutaneous sensation and heat pain threshold) changes between pre and post light brushing Graston technique in patients with Fibromyalgia compared with healthy controls.

Operational Definitions

Healthy: Subject does not exhibit any previous or current musculoskeletal condition, chronic pain, or other health conditions which require medical treatment.

GT: Graston Technique

Light Brushing: Performed with superficial, linear stroking motions in one direction at a time, using only the weight of the instrument (GT3)

GT Treatment: 45-second "light brushing" only treatment using the GT3 instrument

Desensitization: Decrease in pain or responsiveness to touch of a tissue area

ART: Active Release Technique

IASTM: Instrument Assisted Soft Tissue Mobilization

Manual Therapy: A physical treatment used on the musculoskeletal system to treat pain and disability, encompasses massage therapy, myofascial release, ART and IASTM

QST: Quantitative Sensory Testing

Experimental Pain Measurement: Includes cutaneous sensation, heat pain threshold and tolerance, temporal summation

BPI: The Brief Pain Inventory measures clinical pain intensity

VAS: The Visual Analog Scale is a subjective pain scale

TS: Temporal Summation

CHAPTER 2

REVIEW OF LITERATURE

Pain

The International Association for the Study of Pain defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage".[12]

Pain perception can simply be thought of as a wire transmitting electricity. When an injury occurs and the tissue is damaged, it sends signals through pain fibers and those impulses are experienced as pain.[13] However, this theory fails to explain how and why pain is experienced differently by different individuals or why pain is worse at one point in time rather than another.

In 1965, the Melzack-Wall pain gate theory was created.[13] This theory suggests that both large and small nerve fibers are responsible for pain transmission. Similar to a highway, the larger fibers carry most of the traffic. The smaller fibers endure less activity which keeps the "gate" closed so that sensations are not experienced as pain.[13] When tissue damage occurs, there is an overflow of traffic along the larger fibers so the activity increases along the smaller fibers. This opens the "gate" and the sensation is felt as pain.[13]

Types of Pain

Pain is typically separated into two categories, acute and chronic. Acute pain occurs rapidly, as a result of tissue damage. This type of pain can be viewed as an alarm response,

which alerts the person to attend to the cause of pain and prevent further harm.[14] Since acute pain is linked to the inflammatory response, it typically subsides along with the inflammatory process.

Chronic pain, or persistent pain, is defined as a condition lasting 3 months or more.[16] Chronic pain is a widespread problem among the general population. Symptoms related to pain in the musculoskeletal system have been the most common reason for physician and emergency room visits since 1994.[16] Pain is the driving force of health care utilization and lost productivity, while it also places a substantial toll on the patient, their loved ones and society in general.[14] Over time, the body adapts and neurobiological, psychological and social changes occur which allow the body to maintain this pain.[14] Chronic pain becomes a constant factor in an individual's life.

Fibromyalgia

Fibromyalgia is a long term disorder which involves wide-spread chronic pain and tenderness in the joints, muscles, tendons and other soft tissues.[15] Fibromyalgia syndrome is the third most common disease in the United States, following osteoarthritis and rheumatoid arthritis.[3] Due to the presence of widespread pain, patients often have difficulty with normal activities of daily living. As a result, Fibromyalgia syndrome can be very debilitating. Patients with Fibromyalgia have persistent pain in the neck, shoulders, arms, waist and knees.[3] To be diagnosed with Fibromyalgia, the patient must have had body wide pain for at least 3 months, and pain and tenderness in at least 11 of 18 areas (Figure 1).[15]

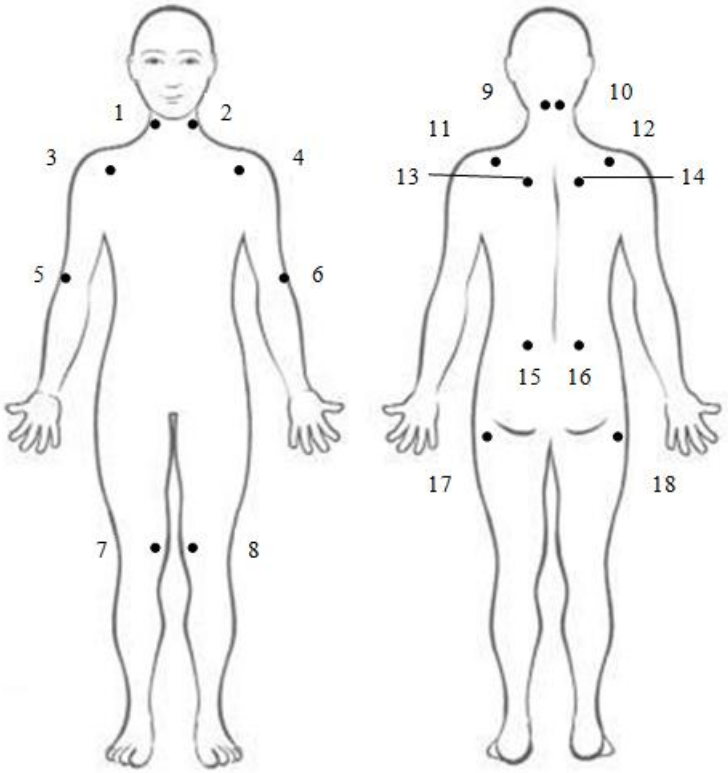

Figure 1. Fibromyalgia 18 Point Diagram.[15]

There is no definite treatment for Fibromyalgia because a single pathophysiological factor has not been identified.[3] Empirical treatment involves the use of modalities and manual therapy to control pain followed by exercise.[3]

Central Sensitization

The decreased pain threshold seen in patients with Fibromyalgia is general, and the peripheral tissues involved are the muscles, skin, bone, tendons and ligaments.[17] It is unlikely that so many types of peripheral tissues would be primarily involved to produce pain. Along with widespread pain, mechanical allodynia is a key characteristic of Fibromyalgia tender points.[17] Experimental studies in patients with Fibromyalgia validated an increased sensitivity to stimuli in areas outside tender point sites, suggesting an abnormality of central pain mechanisms.[17]

Repeated noxious or painful stimulation results in increased or prolonged activity of dorsal horn neurons which may lead to an increase in neuron responsiveness.[18,19] This phenomenon is known as central sensitization. It is characterized by hyper excitability of dorsal horn neurons causing lengthened neuron discharges and an expansion of the receptive field.[20] Consequently, an increase in responses to noxious stimuli is seen in the neuron, known as hyperalgesia, and also a response to non-noxious stimuli, or allodynia.[20]

Recent studies have presented evidence suggesting excitability of the central nervous system in unilateral musculoskeletal conditions.[21] When compared to healthy subjects, those with unilateral musculoskeletal pathologies demonstrated decreased pain thresholds bilaterally, indicating general pain sensitivity.[21]

A study measuring heat pain threshold in both the involved and uninvolved extremity in patients with unilateral shoulder pain did not find a difference between sides.[21] Although no difference was found using heat pain threshold, measurements of pain sensitivity differed when using pressure pain versus thermal pain.[16] Both of these methods measure different aspects of pain processing, which implies there may be differing pain related changes at the local and central level.

Peripheral Sensitization

Tissue injury caused by intense mechanical, thermal or chemical stimuli activates high-threshold sensory neurons, called nociceptors, to produce pain.[22] This is followed by the inflammation process, which triggers the release of inflammatory mediators. These chemicals act to reduce the threshold and increase the responsiveness of peripheral terminals of the high

threshold nociceptor neurons.[22] This phenomenon is known as peripheral sensitization and contributes to pain hypersensitivity.

Pain Measurements

Visual Analog Scale

A Visual Analog Scale (VAS) is an instrument that is designed to measure a characteristic or attitude that is believed to range across a continuum of values.[23] For example, the amount of pain a patient feels ranges along a continuum of 0 to 100 or none to extreme on a 10cm scale. Their pain does not take distinct jumps, as a categorical value of none, mild, moderate or severe would suggest.[23] The VAS has excellent reliability, with an ICC ranging from 0.95-0.98.[24] Since this type of assessment is highly subjective, these scales are more useful when looking at change in one individual over a period of time.

Cutaneous Sensation

Maximillian von Frey is known for his work involving cutaneous sensory mechanoreceptors.[25] He proposed the idea that pain is an independent tactile quality, the same as touch, heat and cold, and that these sensations are associated with the stimulation of free nerve endings.[25] Max von Frey discovered “pain spots” on the skin when probing it at threshold intensity for sensation.[25] Von Frey placed and pressed a single hair on the skin. He then determined the threshold force needed to produce the sensation of touch.[25]

Von Frey created a unique type of esthesiometer, now referred to as a Von Frey hair, which consisted of various calibrated monofilaments.[25] These Von Frey filaments consist of a series of hairs of various thicknesses each mounted at right angles on a bar.[26] The bars are calibrated by measuring the force needed to bend the hair on a weighing pan.[26] They can be used

for determining the threshold force required to produce the sensation of touch, as well as for measuring mechanical pain.[26] A study conducted by Park, Wallace and Schulteis found the Von Frey filaments to have extremely good repeatability and reliability.[26]

Quantitative Sensory Testing

Quantitative Sensory Testing (QST) has been used clinically to assess pain in subjects with different musculoskeletal pain conditions.[16] A method of administering controlled noxious stimuli is used for the purpose of understanding pain perception and exposing which pain pathways and mechanisms may be involved under certain conditions.[16]

A commonly used method involves a "static view" of pain perception, which includes measures of pain threshold and tolerance.[16] These static measures provide basic, one-dimensional assessments of an individual's pain perception.

Another commonly used method involves a "dynamic view", which explores potential pain modulatory mechanisms of the individuals.[16] This view is assessed by temporal summation and conditioned pain modulation. Temporal summation can be induced in humans through the administration of equal nociceptive pulses applied to the skin. The progressive increase in pain perception represents temporal summation.

Static pain measures such as threshold and tolerance may provide a limited view on the pain processing system in comparison to dynamic measures.[16] Measures such as temporal summation which are derived from a dynamic QST approach are thought to better capture the pain modulatory ability of the central nervous system.[27]

Temporal Summation

Temporal summation (TS) is usually evoked by repetitive mechanical or electrical stimuli, or by tonic heat pain.[28] TS is defined as a process in which the duration of a stimulus enhances the induced pain, such that under certain conditions, the last painful stimulus of a constant sequence evokes more pain than the first.[28] Although the patient receives pulses at a constant temperature, they may report that the last pulse is more painful than the first which demonstrates evidence of summation. TS results in the perception of increased pain despite constant peripheral afferent input and is therefore considered a perceptual symptom of enhanced central excitability.[16] It has been demonstrated that enhanced temporal summation of pain causes a "windup" in the dorsal horn neurons and also involves central N-methyl-D-aspartate receptor mechanisms.[16] Therefore, the sensitization that occurs is attributed to a central mechanism, because the effect causes activation of receptors on neurons in the dorsal horn.[16]

Mechanism of Manual Therapy

Many methods of manual therapy including massage, myofascial release, ART and instrument assisted soft tissue mobilization have been proven to have positive effects on pain and soft tissue conditions.[29-32] Manual therapy is a commonly used protocol among clinicians to aid in the management of pain. The purpose of this section is to demonstrate how these techniques are able to have an effect on pain.

Joel Bialosky et al proposed a comprehensive model for the mechanisms of manual therapy.[29] The model illustrates the chain of neurophysiological effects of a brief mechanical stimulus to the tissue. The purpose is to illustrate how these effects produce the clinical outcomes associated with manual therapy in the treatment of musculoskeletal injuries.

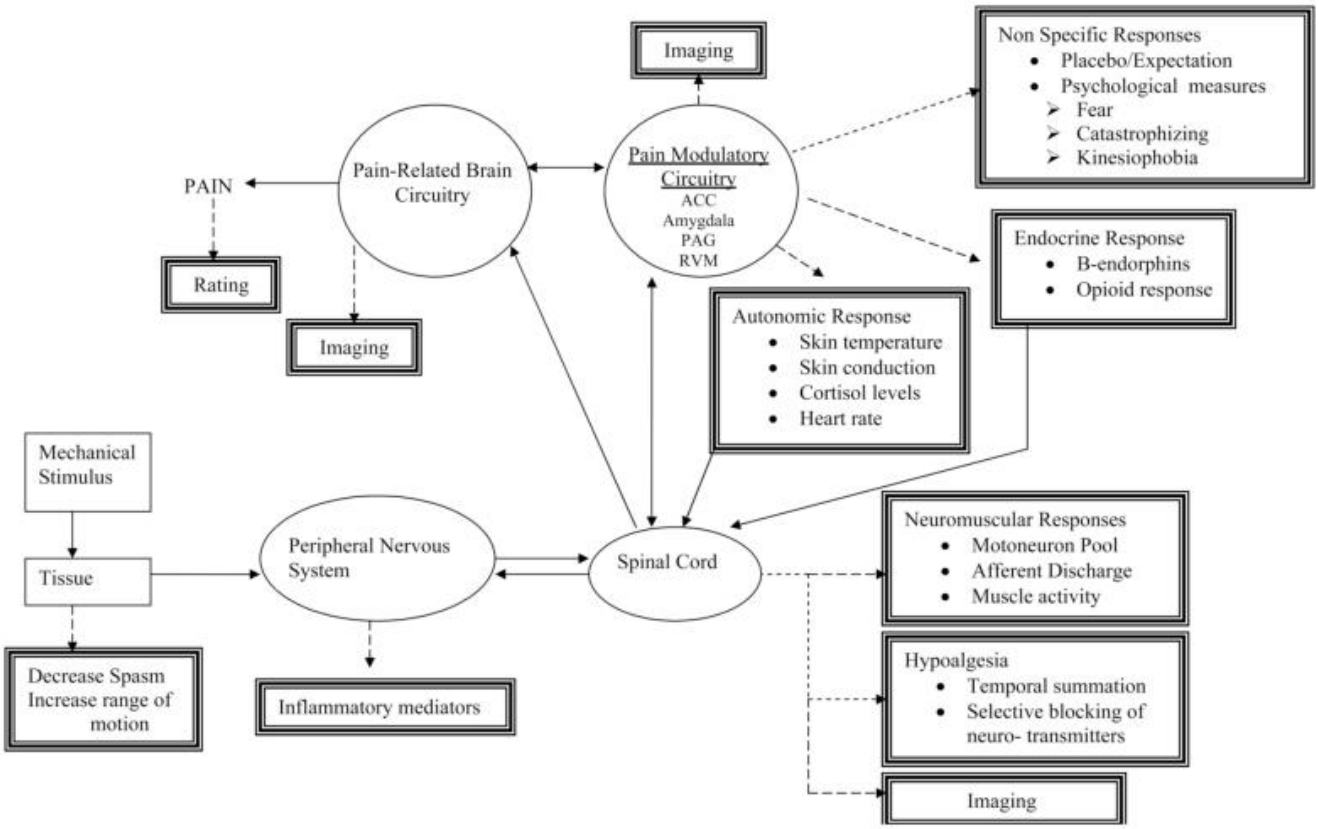

Figure 2. Comprehensive model of the mechanisms of manual therapy.[29]
Figure key: Solid arrows denote a direct mediating effect. Broken arrows denote an associative relationship. Bold boxes indicate the measurement of a construct. ACC=anterior cingular cortex; PAG=periaqueductal gray; RVM=rostral ventromedial medulla.

Mechanical Stimulus

Biomechanical effects have been reported as a result of joint biased and nerve biased manual therapy.[29] Although lasting structural changes have not been noted, manual therapy is believed to improve the signs and symptoms of certain pathologies. Some studies have also reported improvements in signs and symptoms in areas away from the area being treated.[33,34] This suggests a mechanism of not only central, but also peripheral sensitization. The effectiveness of manual therapy suggests that additional mechanisms may be relevant, but a

mechanical stimulus is necessary to initiate the succession of neurophysiological responses which produce the desired effects of manual therapy.

Neurophysiological Mechanism

Joel Bialosky et al proposed that both the central and peripheral nervous systems are involved in the pain response.[29] Current studies of the effect of manual therapy on humans are unable to directly observe the central or peripheral nervous system. In order to draw conclusions about these systems, specific neurophysiological responses are observed. Studies have measured changes in temporal summation following manual therapy to suggest a mechanism caused by the dorsal horn of the spinal cord.[35]

Peripheral Mechanism

Following a musculoskeletal injury, initiation of the healing process and influencing of the pain process is a result of the inflammatory response induced in the periphery.[29] Inflammatory mediators and periphery nociceptors play key roles in the inflammatory response and manual therapy may directly affect this process. Changes such as decreased blood and serum level cytokines, altered acute inflammation and substance P levels were observed following manual therapy.[29] These changes suggest that manual therapy may have an effect on pain mediated by the peripheral nervous system.

Soft Tissue Anatomy and Physiology

Manual therapy techniques affect the tissues on a cellular level in order to have an effect on pain. Soft tissue conditions involving the tendons, ligaments, connective tissue and fascia are often the cause of musculoskeletal pain.

Orthopedic medicine involves the examination, diagnosis and treatment of soft tissue limitations. In order to understand the relevant mechanisms of injury and repair and the rationale for treatment of soft tissue lesions, the soft tissues themselves need to be defined and examined.[36] The main types of soft tissues seen in orthopedic medicine include the connective tissues, muscle tissue and nervous tissue.[36]

Connective Tissue

The connective tissues form a large class of tissues responsible for providing tensile strength, substance, elasticity and density to the body, as well as facilitating nourishment and defense.[36] Formation consists of three components; cells, fibers and ground substance.[6] The framework of the connective tissue is the extracellular matrix made up of protein fibers and ground substance, secreted by fibroblasts.[6] Connective tissue has a major role in repair following trauma and a mechanical role in providing connection and leverage for movement, as well as preventing friction, pressure and shock between mobile structures.[36] Connective tissue is the main focus of treatment procedures in orthopedic medicine.

Fascia

As commonly presented in standard anatomical description, the muscle-bone concept provides an exclusively mechanical model of movement.[37] This concept demonstrates that a muscle is a connection from bone to bone and its purpose is to move that single segment, breaking movement into discrete functions. However, it fails to demonstrate the seamless integration seen throughout a living body.[38] When one part moves, the body as a whole responds. Functionally, the only tissue that can mediate such responsiveness is the connective tissue.[38]

Aside from what muscles do individually, they also influence functionally integrated continuities throughout the body within the fascial webbing.[38] These sheets and lines follow the contour of the body's connective tissue and form traceable 'meridians' of myofascial.[38] Stability, strain, tension and postural compensation are all distributed along these lines.[38]

Histology of Fascia

Myofascia is composed of specific cells, ground substance and fiber types.[39] Taken altogether, the connective tissue cells and their products act as a continuum, as our 'organ of form'.[38] Connective tissue binds every cell in the body to those around it and even connects the inner network of each cell to the mechanical state of the entire body. Part of its connecting nature may lie in its ability to store and communicate information across the body.[38]

Tensegrity

The fascial system conveys mechanical information through tension and compression. This system has a unique way of 'talking' to itself, communicating along the grain of fascia and ground substance, from fiber to fiber and cell to cell, directly.[38] A tug in the fascial net is communicated across the entire system like a snag in a sweater, the whole network is affected.[38] Given the unified nature of the fascial net, we may assume that work in any given area within the net might transmit signaling waves or lines of pull that would affect one or more of the others.

Tensegrity refers to structures that maintain their shape or integrity because of a balance of woven tensile forces throughout the structure. Our myofasciae provide a continuous network of restricting but adjustable tension around individual bones and cartilage as well as organs and muscles.[38] Tensile forces naturally transmit themselves along the shortest distance available. For this reason, the elastic members of tensegrity structures are precisely positioned to efficiently

withstand stress.[38] Because the structure distributes strain along lines of tension, the tensegrity structure may 'give' at some weak point. In similar comparison, a bodily injury may occur due to long term strains in other parts of the body. The injury happens where it does because of inherent weakness or previous injury.[38] Discovering these pathways and easing chronic strain can play a key role in preventing future injuries.

A tensegrity structure is made up of compression members and tension members. Compression members keep the structure from collapsing on itself, while the tensional members keep the compression members in proper alignment in relation to one another. An increase in tension on one members results in increased tension among the other members. All the interconnected elements of a tensegrity model rearrange themselves in response to local stressors.[40] As this stress increases, more members in the surrounding area rearrange to lie in the direction the tension is pulling, resulting in a linear stiffening.[40] If you want to change misalignment of bony structures, you should change the tensional balance through the soft tissue and the bones will rearrange themselves.

Plasticity

Connective tissue responds to the various demands placed upon it by individual activity and injury. The mechanism of connective tissue response and remodeling is important to understand in order to intervene and treat affected areas. Stress passing through a material deforms the structure, even if only slightly, thereby 'stretching' the bonds between molecules.[38] In biological matters, this creates a slight electric flow through the material known as a piezo-(pressure) electric charge.[38] The cells nearby can sense this charge and they respond by augmenting, reducing, or changing the intercellular elements in the area.[38]

When stretched, a muscle will attempt to recoil back to its resting length, but if you stretch fascia quickly, it will tear. If the stretch is applied slowly enough, it will deform plastically: it will change its length and retain that change.[38] In summary, muscle is elastic whereas fascia is plastic.

Adhesion

The fascial components of ground substance and adhesive matrix proteins are linked into the intracellular cytoskeleton. Some kind of adhesive component is necessary to hold the body together. However, this cellular adhesion is found to have a role in many diseases such as asthma, osteoporosis, heart failure, atherosclerosis and stoke as well as mechanical issues including low back and joint pain.[41]

Soft Tissue Response to Damage

When tissue becomes damaged the body treats it as a foreign invader and the inflammatory response is activated. The acute inflammatory reaction begins with chemical mediators released in the injury site to signal local vasodilation and increased vascular permeability which allows infiltration of leukocytes from the surrounding vasculature.[6] Leukocytic activation results in phagocytosis of local particles, the release of lysosomal enzymes, reactive oxygen species and inflammatory mediators such as cytokines and arachidonic acid metabolites.[42] This reaction is necessary to debride the area of damaged tissue however leukocytic activation may also induce injury in otherwise healthy tissue which may prolong the healing process. Outcomes of the acute inflammatory process may be resolution to normal tissue, progression to chronic inflammation or the production of fibrotic tissue.[6]

Soft Tissue Healing

When tissue suffers an injury, the body undergoes a healing process to restore that tissue to normal. This leads to either scarring to replace normal tissue or restoration of normal tissue within the area. The healing process is broken down into three phases: the inflammation phase, the proliferation phase and the maturation or remodeling phase.[43]

Inflammation is a necessary process as it is the first step to recovery. This phase begins at the time of the injury as the body immediately responds to trauma. When an injury occurs, blood vessels in that area become damaged and substances are released to start the healing process. Due to an increase in blood flow and an increase in the permeability of the vessels, blood, plasma and tissue fluids rush into the area.[43] Platelets enter the area and bind to the exposed collagen to stimulate the clotting mechanism.[43] Within 24 hours macrophage-like cells enter the area and debride the injury site necrotic tissue, debris and foreign material.[43] Toward the end of this phase, fibroblasts migrate to the area which begins the proliferation phase. These fibroblasts will be responsible for producing collagen which will turn into scar tissue.[43]

During proliferation, there is an accumulation of fibroblasts, myofibroblasts and endothelial cells. The combination of a new capillary system along with the fibroblasts and myofibroblasts is known at granulation tissue.[43] This accumulation results in a decrease in the original fibrin clot, as the granulation tissue assists in creating a more permanent structure. The amount of collagen in the area has increased which increases the tensile strength of the wound.[43] As the transition is made between the proliferation phase and the maturation phase, changes occur in the scar tissue. The scar becomes more dense as the collagen fibers continue to mature and become more densely packed.[43]

The maturation or remodeling phase is the final phase in the healing process and may last a year or more following the time of the injury. As stress is applied to collagen in this phase, dense bundles begin to form and the fibers become more organized.[43] Throughout this final phase, the new tissue is remodeled until it either restores the area to its former structure or it replaces the former structure with a scar.

Proposed Mechanism of Treatment

History of Massage Therapy

Massage therapy is the manual manipulation of soft tissue to promote physical health and well being.[30] Massage is a manual therapy technique that has been practiced for many centuries. Treatments can be dated back to as far as 2,000 BC.[30] This technique has been used to treat a variety of conditions. Some of its uses include alleviating pain, increase fluid mobilization and increase soft tissue mobilization.

Soft Tissue Mobilization

Myofascial Release

Myofascial release is a massage technique that focuses on soft tissue that is tight and causing pain or restrictions.[30] The cause of the tightness could be a muscle spasm, soft tissue adhesions or scar tissue.[30] These areas of muscle spasm are often referred to as trigger points. A trigger point is most commonly found in the belly of a muscle and can be defined as “a hypersensitive palpable nodule within a taut band” of muscle tissue.[30]

To locate a trigger point, the clinician palpates the muscle tissue perpendicular to its fibers and feels for a nodule. Two types of myofascial techniques have been identified in the literature. The first involves a direct application of pressure to the adhesion or spasm, whereas the second involves a slow, sweeping pressure.[30] Pressure is applied to the area and held for 60-90 minutes, but may be held as long as five minutes, and then gradually released.[30] The slow, sweeping pressure promotes tissue extensibility, while breaking up scar tissue and adhesions. Direct pressure is used to dissipate adhesions and muscle spasms. Soft tissue mobilization starts superficially and progresses into the deeper layers of the tissue.

A limitation of myofascial release is the time and physical wear required by the clinician. Many athletic trainers have a large number of athletes which makes massage-type treatments too time consuming.

Active Release Technique

Active Release Technique (ART) is a manual therapy technique used to treat soft tissue injuries. The clinician uses palpation to locate areas of tensions or adhesion in a specific tissue. Then the tissue is taken from a shortened position to a lengthened position while using manual contact to maintain tension along the fibers.[31]

Instrument Assisted Soft Tissue Mobilization

Traditional soft tissue manipulation is performed manually by the care provider's bare hands, using the fingertips to localize aberrant tissue and to perform manual treatment of the area.[6] Due to the stress of manual massage techniques on the caregiver's hands, specifically the first digit, instrument assisted soft tissue techniques have become favored by many as they

reduce the stress on the operator and are regarded as more sensitive to localizing aberrant tissue compared to the care giver's fingertips.[6]

Gua Sha

Gua Sha is an instrument-assisted unidirectional "press stroking" of a lubricated area of the body surface that intentionally creates transitory therapeutic petechiae.[32] These petechiae, which fade within 2-5 days, result from the extravasation of blood into the subcutis.[44] While they and their accompanying ecchymosis appear remarkable, Gua Sha therapy is generally well tolerated with litter or no discomfort. The technique is traditionally used in the treatment of both acute and chronic neck and back pain.

Lauche et al performed a study to measure the effects of Gua Sha IASTM therapy pain ratings and pressure pain thresholds of patients with chronic neck pain and patients with chronic low back pain.[32] A total of 40 participants were randomized and placed into either a treatment group or a control group. All patients rated their baseline pain on a visual analog scale. PPT measurements were then taken at a site of maximal pain and at an adjacent site.[32] The treatment group then received one session of Gua Sha therapy. Post-intervention measurements were taken seven days after the baseline assessment using the same VAS and PPT measurements. Patients experiencing chronic neck pain and patients with chronic low back pain both reported pain reduction ($p<0.05$) and improved health status from their one treatment.[32] These results suggest that Gua Sha therapy may be an effective treatment for patients with chronic neck or low back pain.

Graston Technique

The Graston Technique is an innovative, patented form of instrument-assisted soft tissue mobilization that enables clinicians to effectively break down scar tissue and fascial restrictions.[7] GT is derived from the theory of cross friction massage. The technique utilizes specially designed stainless steel instruments to specifically detect and effectively treat areas exhibiting soft tissue fibrosis or chronic inflammation.[7]

History of Graston

In 1987, David Graston sustained an injury to his knee while water skiing. The injury was treated traditionally with limited recovery of range of motion.[45] Graston began self treating the area of injury with a rigid piece of metal which resulted in a significant increase in range of motion. Using his prior experience in the tool and die industry he began the development of a set of instruments. Together with a business partner, Michael I. Arnolt, they formed TherapyCare Resources, Inc and together with local outpatient clinics began clinical research.[45]

Mechanism of Graston Technique

The Graston Technique is proposed to work by infiltrating areas of soft tissue injury, separating and breaking down collagen cross-links in order for the tissue to heal in a linearly, organized fashion.[6] This theoretically stretches out the tissue to increase the segmental range of motion as well as increased range of motion globally, through the kinetic chain.[46] This patented form of IASTM enables clinicians to effectively break down scar tissue and fascial restrictions. GT utilizes specially designed instruments and various strokes to specifically detect and effectively treat areas exhibiting soft tissue fibrosis or chronic inflammation.[9] GT could be a

useful resource as it targets the underlying problems in the tissues rather than simply treating the symptoms the individuals are experiencing.

Graston Treatment Stokes

Table 1 is a summary of the seven treatment strokes utilized with the Graston Technique.

Table 1. Graston Technique Treatment Strokes.[47]

Stroke	Description
Sweep	This stroke can be used by all instruments. The sweep is performed by moving the instrument in one direction at a constant rate in either a linear or curvilinear pattern. This stroke is used for scanning an area to be treated to locate adhesions or to reduce edema.
Fanning	This stroke is used best with GT1, GT2, GT4 or GT5. The fanning stroke is performed by fixating one end of the instrument and moving the opposite end in an arc pattern. This stoke is used to localize and area to be treated.
Brushing	This stroke is used with GT3. The brushing stroke is performed with superficial, linear stroking motions with small amplitude. This is a multi-directional treatment however, brushing occurs in one direction at a time, not back and forth. This stroke is used for desensitization of an area prior to more aggressive treatment strokes or mobilization of superficial fascia. Brushing treatment lasts for 30-60 seconds.

Table 1 Continued.

Strumming	This stroke can be used with GT1, GT3 or GT4. Strummed is performed with deep, linear stroking motions with small amplitude. It is performed in one direction at a time and perpendicular to the fibers being treated. This stroke is used for mobilization of specific restrictions.
J-Stroke	This stroke is used with GT3. This J-stroke is performed by forming a letter "J", and can be either superficial or deep. It is used to mobilize superficial or deep restrictions.
Swivel	This stroke can be used with GT1 or GT2. The swivel stroke is performed by using a rocking motion back and forth. It is used for the relaxation of soft tissue.
Scooping	This stroke can be used with GT2 or GT6. Scooping is performed just how it sounds, by simply "scooping" the tissue, much like scooping ice cream. It can be performed in multiple directions and is used to break up soft tissue lesions.

Graston Instruments

Graston Technique utilizes six patented, uniquely shaped stainless steel instruments that are advertised to be designed for efficient and effective soft tissue treatment.[6] These instruments may be applied to treat a variety of conditions including scar tissue development, myofascial

trigger points, headaches, muscular hypertonicity, tendinosis, ligamentous sprains and cumulative trauma disorders.[6] They are made of high chromium stainless steel that transmits vibrations so the clinician is able to locate adhesions.[8] Each instrument is designed to fit different body parts. The shapes of the treatment edges are concave to treat convex areas and vice versa. This makes the treatment more comfortable for the patient, as the pressure is able to be equalized over the area.[8] The treatment surfaces of the instruments are either single or double beveled. The instruments are ergonomically designed to reduce strain and fatigue for the practitioner. A mechanical advantage is provided for soft tissue techniques.[8] The larger and broader instruments can be used to scan over large areas and can accommodate two hands.

Clinical Considerations

Assessing pain in humans using QST has recently become more advanced and provides the possibility of determining which pain pathways and mechanisms are involved, impaired or affected.[48] The ultimate goal is to obtain a better understanding of pain transmission and perception under pathophysiological conditions. Treatment of pain relies on the understanding of certain mechanisms of the pain-perception system.

Currently, a variety of manual therapy methods are used to alleviate chronic pain including massage, myofascial release and active release technique. These techniques have been proven to decrease pain and disability in patients with chronic pain.[4-7,9-10] The Graston Technique for soft tissue mobilization may be an additional method clinicians can employ to treat pain. The light brushing GT stroke is proposed to desensitize a painful or hypersensitive area prior to more aggressive stages of the protocol.[47] No studies to date have evaluated the effect of the light brushing stroke on patients with pain.

If the light brushing GT is proven to decrease pain in chronic patients, it could become a novel technique in the clinical setting. The treatment time is much shorter than other modalities used to decrease pain such as heat, ice or electrical stimulation, which makes it more efficient.[1] Chronic pain is an ongoing problem in our society, therefore any new effective treatment options may be extremely beneficial.[2]

CHAPTER 3

METHODS

Design Statement

This study was an experimental, cross sectional design with pretest and posttest measures.

Independent Variables:

Treatment- GT light brushing

Group- Fibromyalgia and Healthy

Dependent Variables:

Cutaneous Sensation- measured using Von Frey filaments (mN)

Heat Temporal Summation- heat pulses were emitted using a contact thermode with a 2.5-cm^2 surface area. Stimuli were then measured using a computer-controlled neurosensory analyzer (TSA-2001; Medoc, Inc, Ramat Yishai, Israel).

Heat Pain Threshold- Thermal stimuli were applied to both forearms by placing a contact thermode on the volar surface. The stimuli were measured using a computer-controlled neurosensory analyzer (TSA-2001; Medoc, Inc, Ramat Yishai, Israel).

Participants

Twenty healthy participants and twenty patients who have met the American College of Rheumatology (ACR) diagnosis criteria for Fibromyalgia were recruited. The ACR form uses

check boxes to collect data regarding widespread pain index, location of pain in the past week, Symptom Severity Scale (SS Scale) for fatigue, waking un-refreshed and cognitive symptoms; and other somatic symptoms.

Subjects had to be able to read and speak English because many self-report questionnaires were used. General exclusion criteria included a known neuropathic or nerve injury, the use of pain or psychiatric medications, contraindication to heat, unhealed or unstable fracture, open wounds, thrombophlebitis, uncontrolled hypertension, hematoma, osteomyelitis, myositis ossificans or hemophilia.[38] Participants were excluded if they had any previous history of chronic pain conditions such as myofascial pain syndrome, osteoarthritis, rheumatoid arthritis or cancer. Healthy participants over the age of 40 were recruited to match the typical age range of Fibromyalgia patients.

Instruments

Clinical Pain Measurement

The Brief Pain Inventory (BPI)

Clinical pain was assessed with the Brief Pain Inventory, which uses an 11-point numerical rating scale for pain intensity.[20] The scale dictates that 0 is scored as “no pain at all” and 10 is scored as “the worst pain imaginable”. Participants rated their pain for three circumstances: current pain intensity, worst pain intensity over the last 24 hours, and the best pain intensity over the last 24 hours. The three pain ratings were added together and divided by three, in order to determine the average clinical pain rating.

The BPI was designed to provide information about pain intensity as well as the degree to which pain interferes with function.[49] The inventory also asks questions about pain relief, pain quality, and the patient's perception of the cause of pain.

Visual Analog Scale (VAS)

Clinical pain was assessed with a Visual Analog Scale, which is an instrument that is designed to measure a factor that is believed to range across a continuum of values.[23] The patient was asked to indicate the amount of pain he or she felt by marking along a continuum of 0 to 100 or none to extreme on a 10cm scale. The VAS has excellent reliability, with an ICC ranging from 0.95-0.98.[24]

Fibromyalgia participants were asked to circle their three most painful points on the Fibromyalgia 18 Point Diagram. They were then required to rate their pain at each point using the VAS. These three points will be used as testing and treatment sites throughout the procedure.

The three most common tender points in Fibromyalgia patients include right suboccipital (point 10), right trapezius (point 12), and right supraspinatus (point 14).[50] For our study, these three points served as the testing and treatment points for all healthy participants.

Experimental Pain Measurement

Thermal Pain Threshold and Tolerance

Thermal stimuli were applied to both forearms by placing a contact thermode on the volar surface. The stimuli were measured using a computer-controlled neurosensory analyzer (TSA-2001; Medoc, Inc, Ramat Yishai, Israel). The temperature of the thermode was slowly increased at a rate of 0.5˚C/s until the patient reported the first sensation of pain. The temperature was then

recorded as the threshold and participants were asked to rate the pain intensity that they felt on a scale of 0 to 100, with 0 being no pain and 100 being the most intense pain sensation imaginable.

In a separate trial to determine tolerance, the same temperature parameters were performed. In this trial, participants reported when the temperature became intolerable. Pain intensity was recorded and temperature was then recorded at tolerance. Two trials of both threshold and tolerance were performed and the average of these trials was used for data analysis. Previous studies determining the reliability of thermal pain testing have reported minimal intraindividual differences and good test-rest reliability.[20]

Heat Temporal Summation

Temporal summation was measured using a contact thermode with a 2.5-cm^2 surface area which delivered a series of heat pulses to the thenar eminence of both hands. The participant felt a series of five continuous pulses less than 1 second of duration of a constant temperature. The first trial was conducted at a temperature of 48˚C, and the second at 50˚C. Participants were asked to rate the pain intensity that they felt after each pulse on a scale of 0 to 100, with 0 being no pain and 100 being the most intense pain sensation imaginable. They were also asked to continue to rate their pain intensity every 15 seconds for the next 30 seconds. This test was repeated 2 times, waiting 60 seconds between each trial.

Cutaneous Sensation

Cutaneous sensation was measured using Von Frey monofilaments. Von Frey monofilaments provide a noninvasive evaluation of cutaneous sensation levels throughout the body with results that are objective and repeatable. Each monofilament is individually calibrated to deliver its targeted force within a 5% standard deviation. The pain threshold is defined as the

logarithmic number of a monofilament, which expresses the force exerted by this monofilament that is reported as painful by the subject.[51] The Von Frey monofilaments are calibrated in a logarithmic scale from 0.008 to 300 grams (0.08 – 2943 mN), within a 5% standard deviation. Numbers on each monofilament ranging from 1.65 to 6.65, representing the common logarithm of 10 times the force in milligrams.[52]

Testing was done in a quiet area to help the subject fully attend to the testing procedure. The subject was asked to close their eyes so they could not see when a stimulus was being applied. The subject was instructed to respond when the stimulus is felt by saying "yes".

Filament sizes were chosen at random. The filament was pressed against the skin at a 90 degree angle until it bowed. Each filament was held in place for 1.5 seconds and then removed. For monofilaments from units 1.65 to 4.08, the stimulus was applied in the same location up to three times to elicit a response. For filaments 4.17-6.65, the stimulus was only applied once.

A single response from the patient indicated a positive response. Once a monofilament evoked a response, the monofilament 1 unit smaller was used. If there was no response, the monofilament 1 unit larger was used again and upon a positive response, the unit was recorded.

Procedure

Participants were placed into 2 cohorts, the healthy cohort and the Fibromyalgia cohort. All participants were educated about the purpose of the study and signed an informed consent form. Subjects completed a Health History Questionnaire to check for exclusion criteria, followed by a Demographic form. Subjects in the Fibromyalgia cohort completed the ACR Diagnosis Criteria form, the Fibromyalgia Impact Questionnaire (FIOR), and the Pain Self

Efficacy Questionnaire (PSEQ). If a patient in the Fibromyalgia cohort does not meet the ACR Fibromyalgia criteria, they will be removed from the study.

Clinical pain intensity was then assessed in all subjects using the Brief Pain Inventory (BPI). All subjects completed the Pain Catastrophizing Scale (PCS), Patient Health Questionnaire (PHQ-9), Self Evaluation Questionnaire (STAI), and the Life Orientation Test (LOT-R) to determine their attitudes towards and perception of pain. Subjects then completed a questionnaire to establish their perceived effect of the treatment, and one to determine their perceived pain sensitivity as compared to others.

Subjects in the healthy cohort rated their pain at points 10, 12 and 14 using the Visual Analog Scale (VAS). Subjects in the Fibromyalgia cohort identified their top three most painful sites and rated the pain at each using the VAS. These three points were used as the testing and treatment points throughout the remainder of the study. All subjects completed the Emotional Assessment Scale (EAS) before and after the treatment to determine their level of happiness, anxiety, fear and relaxation.

Subjects underwent the baseline experimental pain assessment, which consisted of the measurement of thermal pain threshold and thermal pain tolerance (performed on the volar surface of the forearm), heat temporal summation (performed on the thenar eminence) and cutaneous sensation (at 3 sites identified on the VAS form). All assessments were performed bilaterally.

Participants then received a 45-second light brushing only Graston treatment over each of the 3 points that were previously identified. This treatment was performed using the GT3 instrument.

Immediately following the treatment, the participants underwent the post-test experimental pain assessment. Measurements consisted of cutaneous sensation (at the same 3 sites), thermal pain threshold, thermal pain tolerance, heat temporal summation.

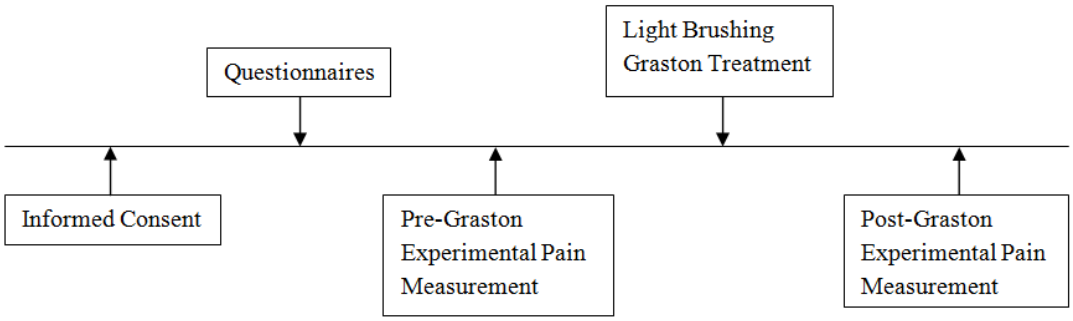

Figure 3. Session Timeline

Statistical Analysis

Repeated measures ANOVA were used to assess the effect of treatment (pre and post Graston technique) on cutaneous sensation, TS, and heat pain threshold by groups (Fibromyalgia group vs healthy controls). For this analysis the between subjects factor was the groups (Fibromyalgia group vs healthy controls), and the within subjects factor was the treatment (pre and post Graston technique).

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CHAPTER 4

MANUSCRIPT

Effects of Light Brushing on Clinical Pain Intensity and Experimental Pain Sensitivity in Fibromyalgia Patients

Introduction

Millions suffer from acute or chronic pain every year.[1] The effects of pain place a tremendous strain on our country in health care costs, rehabilitation and lost worker productivity.[1] Pain also places an emotional and financial burden on patients as well as their families.[2] Pain affects more Americans than diabetes, heart disease and cancer combined.[1] More than 25% of Americans 20 years of age and older, or an estimated 76.5 million Americans, reported that they have had pain that persisted for more than 24 hours.[2] Among the symptoms causing chronic pain, Fibromyalgia syndrome is one of the leading causes of labor loss and expenditures of medication and therapy.[3] Fibromyalgia is a chronic pain condition that causes changes in the central nervous system, which effects the way the body processes pain.[3]

Many different modalities and techniques have been employed in a variety of settings in attempts to decrease pain, such as manual therapy, heat, ice and electrical stimulation.[1] Manual therapy techniques are often utilized to help decrease pain caused by chronic musculoskeletal conditions, as studies have shown that the use of manual therapy is effective in decreasing pain

and disability.[4,5] Manual therapy commonly includes massage therapy, joint mobilization, myofascial release and active release technique among other forms. Methods such as manual therapy and massage have been proven to decrease pain and disability in injured subjects.[4-8]

These techniques, especially when performed often, can become fatiguing and difficult on the clinician's hands.[9] To overcome this obstacle, instrument assisted soft tissue mobilization techniques (IASTM) have become more popular, including Gua Sha and Graston Technique.[9]

The Graston Technique (GT) is an instrument-assisted soft tissue mobilization technique based on the concepts of manual therapy and cross friction massage.[10] GT utilizes six stainless steel instruments to detect and treat soft tissue restriction. Eight basic treatment strokes are taught with Basic M1 GT training. The "light brushing" stroke is proposed to desensitize the hyper sensitive treatment area prior to more aggressive stages of the protocol.[11] However the evidence supporting a desensitization process is conflicting. Donahue, Docherty and Schrader conducted a study to determine the effect of the light brushing Graston Technique on Pressure Pain Threshold (PPT) measurement in healthy subjects.[7] No significant difference was identified and they concluded that light brushing Graston Technique was not able to desensitize the test site.[10] The main limitation is they used healthy participants with no pain. Therefore, the Graston Technique may have the potential to be an additional intervention tool that clinicians could use in the treatment of pain and soft tissue conditions. However, understanding the mechanisms of Graston Technique could enhance clinical effectiveness and add important information to the currently limited literature.

Therefore, the purposes of this cohort study were: 1) to determine the effect of the light brushing Graston Technique on central and peripheral processing of pain and 2) to determine

differential changes of the light brushing Graston Technique between patients with Fibromyalgia and healthy controls.

Methods

Participants

This cross-sectional cohort study included 8 healthy participants and 11 patients with Fibromyalgia. Patients were recruited from newspaper ads in the Tribune Star and the Clintonian, advertisements posted in public places such as the ISU Recreation Center, YMCA, and local pain management clinic.

The inclusion criteria for being a participant in the Fibromyalgia cohort were: (a) patients who have met the American College of Rheumatology (ACR) diagnosis criteria for Fibromyalgia[12], (b) between the ages of 35 and 85, and (c) Subjects had to be able to read and speak English because many self-report questionnaires were used. General exclusion criteria for being a participant in the Fibromyalgia group included: a known neuropathic or nerve injury, the use of pain or psychiatric medications, unhealed or unstable fracture, open wounds, thrombophlebitis, uncontrolled hypertension, hematoma, osteomyelitis, myositis ossificans or hemophilia.[13]

The inclusion criteria for being a participant in the healthy control group were: (a) subjects between 35 and 85 years of age, and (b) English speaking. Participants were excluded if: (a) they had any previous history of chronic pain conditions such as myofascial pain syndrome, osteoarthritis, rheumatoid arthritis or cancer, (b) they were experiencing pain or have a sensory

impairment, (c) if they were taking pain medication. Healthy participants were recruited to age and sex match the Fibromyalgia patients.

Measurements and Instrumentation

Visual Analog Scale (VAS)

Clinical pain was assessed with a Visual Analog Scale, which is an instrument that is designed to measure a factor that is believed to range across a continuum of values.[14, 15] Fibromyalgia participants were asked to circle their three most painful points on the Fibromyalgia 18 Point Diagram (Appendix A). They were then required to rate their pain at each point using the VAS. These three points will be used as testing and treatment sites throughout the procedure. The patient was asked to indicate the amount of pain he or she felt by marking along a continuum of 0 to 100 or none to extreme on a 10cm scale. The VAS has excellent reliability, with an ICC ranging from 0.95-0.98.[16]

According to the literature, the three most common tender points in Fibromyalgia patients include right occiput at suboccipital muscle insertions (point 10- site A), right trapezius muscle at midpoint of the upper boarder (point 12- site B), and right supraspinatus muscle at origin above the medial border of the scapular spine (point 14- site C), (Appendix B).[17] Therefore, for our study, these three points served as the testing and treatment points for all participants.

Thermal Pain Threshold and Tolerance

Thermal stimuli were applied to both forearms by placing a contact thermode on the volar surface. The stimuli were measured using a computer-controlled neurosensory analyzer (TSA-2001; Medoc, Inc, Ramat Yishai, Israel). The temperature of the thermode was slowly increased

at a rate of 0.5˚C/s until the patient reported the first sensation of pain. The temperature was then recorded as the threshold and participants were asked to rate the pain intensity that they felt on a scale of 0 to 100, with 0 being no pain and 100 being the most intense pain sensation imaginable.

In a separate trial to determine tolerance, the same temperature parameters were performed. In this trial, participants reported when the temperature became intolerable. Pain intensity was recorded and temperature was then recorded as tolerance. Two trials of both threshold and tolerance were performed and the average of these trials was used for data analysis. Previous studies determining the reliability of thermal pain testing have reported minimal intraindividual differences and good test-rest reliability.[18]

Cutaneous Sensation

Cutaneous sensation was measured using Von Frey monofilaments. Von Frey monofilaments provide a noninvasive evaluation of cutaneous sensation levels throughout the body with results that are objective and repeatable.[19] Each monofilament is individually calibrated to deliver its targeted force within a 5% standard deviation. The Von Frey monofilaments are calibrated in a logarithmic scale from 0.008 to 300 grams (0.08 – 2943 mN), within a 5% standard deviation. Numbers on each monofilament ranging from 1.65 to 6.65, representing the common logarithm of 10 times the force in milligrams.[20]

Testing was done in a quiet area to help the subject fully attend to the testing procedure. The subject was asked to close their eyes so they could not see when a stimulus was being applied. The subject was instructed to respond when the stimulus is felt by saying “yes”.

Filament sizes were chosen at random. The filament was pressed against the skin at a 90 degree angle until it bowed. Each filament was held in place for 1.5 seconds and then removed.

For monofilaments from units 1.65 to 4.08, the stimulus was applied in the same location up to three times to elicit a response. For filaments 4.17-6.65, the stimulus was only applied once.

A single response from the patient indicated a positive response. Once a monofilament evoked a response, the monofilament 1 unit smaller was used. If there was no response, the monofilament 1 unit larger was used again and upon a positive response, the unit was recorded.[19]

Overall Procedure

Participants from both cohorts (healthy cohort and Fibromyalgia cohort) were educated about the purpose of the study and completed a Health History Questionnaire to check for exclusion criteria. Subjects in the Fibromyalgia cohort completed the ACR Diagnosis Criteria form to accurately check the inclusion criteria.[21] All subjects enrolled in the study provided informed consent before study participation, followed by a demographic form.

Study participants completed a standard intake demographic information form. Data collected include gender, age, employment status, litigation status, marital status, educational level, and health history. Historical data include the type of onset of symptoms, the length of time of the symptoms, and the number of previous episodes of musculoskeletal pain. Clinical pain intensity was then assessed in all subjects using the Brief Pain Inventory (BPI).

Subjects from both cohorts rated their pain at points 10 (right occiput), 12 (right trapezius muscle) and 14 (right supraspinatus muscle) using the Visual Analog Scale (VAS). Since these three points have been previously described to be the most painful sites in patients with Fibromyalgia.[17] These three points were used as the testing and treatment points throughout the remainder of the study.

Subjects underwent the baseline experimental pain assessment, which consisted of the measurement of thermal pain threshold and thermal pain tolerance (performed on the volar surface of the forearm), and cutaneous sensation (points 10, 12 and 14). All assessments were performed bilaterally.

Participants then received a 45-second light brushing GT stroke over each of the 3 points (points 10, 12 and 14). This treatment was performed using the GT3 instrument by a GT trained clinician.

Immediately following the treatment, the participants underwent the post-test experimental pain assessment, which consist in the same assessment previously described (cutaneous sensation, thermal pain threshold, thermal pain tolerance).

Statistical Analysis

Data analysis was conducted using SPSS, Version 20. Significance levels were set a priori at $p<0.05$ for all comparison. Descriptive statistics (mean, standard deviation) were calculated for all variables. The distributions of variables were tested for normality by visual examination and with Kolmogorov-Smirnov test before used in analysis. For analysis purposes both consecutive measurements of heat pain threshold and heat pain tolerance were averaged into one score.

Repeated measures ANOVA were used to assess the effect of treatment (pre and post Graston technique) on cutaneous sensation, heat pain threshold and tolerance by groups (Fibromyalgia group vs healthy controls). For this analysis the between subjects factor was groups (Fibromyalgia group vs healthy controls), and the within subjects factor was treatment (pre and post Graston technique).

Results

A total of 11 subjects from the Fibromyalgia cohort, and 8 subjects from the healthy cohort were included in this analysis. Descriptive statistics for the demographics from both cohorts are summarized in Table 2.

Table 2. Demographic Characteristics and Summary of the Sample

Subject's characteristics	**Fibromyalgia Cohort N=11 Mean (SD)**	**Healthy Cohort N=8 Mean (SD)**
Age	56.55 (11.34)	49(6.85)
Gender:		
Male	2 (18.2%)	1 (12.5%)
Female	9 (81.8%)	7 (87.5%)
Height (inches)	65.18 (2.23)	67.63 4.69)
Weight (pounds)	179.45 (47.06)	195.63 (65.97)
Ethnicity:		
Hispanic or Latino	0	0
Not Hispanic or Latino	10 (90.91%)	8 (100%)
Prefer not to answer	1 (9.09%)	0
Race:		
Asian	0	0
Native Hawaiian or Other Pacific Islander	0	0
Black or African American	0	0
White	10 (90.91%)	8 (100%)
Prefer not to answer	1 (9.09%)	0
Dominant Hand:		
Right	11 (100%)	8 (100%)
Left	0	0
Employment Status:		
Full-time	5 (45.45%)	6 (75%)
Part-time	2 (18.18%)	1 (12.5%)
Unemployed	0	1 (12.5%)
Disabled	2 (18.18%)	0

Table 2 Continued.

Retired	2 (18.18%)	0
Students	0	0
Prefer not to answer	0	0
Relationship Status:		
Single	1 (9.09%)	1 (12.5%)
Married	4 (36.36%)	7 (87.5%)
Living with significant other	2 (18.18%)	0
Divorced/ Separated	2 (18.18%)	0
Widowed	2 (18.18%)	0
Prefer not to answer	0	0
Level of Education:		
Less than high school	0	0
High school diploma	1 (9.09%)	1 (12.5%)
Some college	7 (63.63%)	1 (12.5%)
Graduated college	0	3 (37.5%)
Some post-graduate work	1 (9.09%)	0
Post-graduate degree	1 (9.09%)	3 (37.5%)
Prefer not to answer	1 (9.09%)	0
Income:		
Less than $20,000	1 (9.09%)	0
$20,000-$35,000	6 (54.54%)	0
$35,000-$50,000	1 (9.09%)	0
$50,000-$70,000	1 (9.09%)	3 (37.5%)
Greater than $70,000	1 (9.09%)	4 (50%)
Prefer not to answer	1 (9.09%)	1 (12.5)
Pain duration (months)	144 (97.79)	0
Previous rehabilitation:		
Yes	7 (63.64%)	0
No	4 (36.36%)	8 (100%)
Surgery within the past 6 months:		
Yes	0	0
No	11 (100%)	8 (100%)

Repeated measures ANOVA was used to assess the effect of treatment on cutaneous sensation, heat pain threshold and tolerance by groups. Measures on each side were analyzed separately to identify effect on the treated (right) vs untreated (left) side.

The interaction terms (treatment*group) were not significant for tolerance in the treated side [F(1,17)= 0.12; p=0.73], and untreated side [F(1,17)=0.32; p=0.58]. The interaction terms (treatment*group), were also not significant for pain threshold in the treated side [F(1,17)= 0.48; p= 0.5], and untreated side [F(1,17)= 2.6; p= 0.13]. Non-significant main effects were found.

For the cutaneous sensation, the interaction term (treatment*group) at site A (occiput) were not significant on the treated [F(1,17)= 1.41; p= 0.25], or untreated side [F(1,17)= 0.34; p= 0.57]. The results at site B (trapezius) indicated there were no significant interaction terms on the treated [F(1,17)= 0.05; p= 0.82], or untreated side [F(1,17)= 2.06; p= 0.27]. The interaction term for site C (supraspinatus) were not significant on the treated side[F(1,17)= 1.31; p= 0.27], or untreated side [F(1,17)= 2.95; p= 0.10] However, the main effect of treatment was significant at site C on the treated side [F(1,17)= 5.6; p= 0.03].

Discussion

This study investigated whether the light brushing GT has an effect on central or peripheral pain processing. In addition, this study investigated potential differences on the effect of the light brushing GT between patients with chronic pain (Fibromyalgia patients), and healthy controls. The present study presents novel data that extends previous work in several ways.[7] First, this is the first study investigating the effect of the light brushing GT on central pain mechanisms. Second, this study attempted to compare the efficacy of the light brushing GT in two different cohorts- a population with chronic pain, and without pain. Overall, this study revealed that (1) there was no effect on central sensitization in either cohort and (2) there was a significant main effect on cutaneous sensation at the most painful location.

No previous studies have been conducted to determine the effects of light brushing on chronic pain conditions. Donahue, Docherty and Schrader conducted a study to determine the effect of the light brushing GT on Pressure Pain Threshold (PPT) measurement in healthy subjects.[7] No significant difference was identified in PPT values.[7] However, the main limitation was the use of healthy participants with no pain. In our study, we investigated the light brushing GT in patients with a chronic pain condition (Fibromyalgia), and the healthy cohort served as the control. There were no significant differences between pre and post treatment on pain tolerance or threshold in either cohort. From these results, we can conclude the light brushing GT had no effect on static measures of central pain processing. Changes in sensitivity may be a precursor to subsequent changes in clinical outcomes that take more time to manifest. Previous manual therapy-related studies found within-session changes are associated with longitudinal changes in clinical outcomes, and initial changes in the periphery may result in similar central changes given enough time. [22,23]

Significant difference between pre and post cutaneous sensation measurements demonstrates that the light brushing GT had a main effect in the periphery. This finding indicates that the technique was able to desensitize the area, as the increase in cutaneous sensation measurement after treatment demonstrates it took more pressure for the subject to feel something. Desensitization is the first step towards decreasing pain. The light brushing GT's ability to decrease pain may be an additional intervention clinicians can use in the treatment of soft tissue injuries as well as chronic conditions.

Cutaneous sensation at the right supraspinatus muscle at origin above the medial border of the scapular spine, demonstrated a significant change between pre and post treatment

measures. This result indicates that the light brushing technique was successful at desensitizing the tissue in that area. Other studies need to be conducted to see how light brushing can affect painful area caused by injury.

Joel Bialosky et al proposed a comprehensive model for the mechanisms of manual therapy.[15] The purpose is to illustrate the chain of neuromuscular effects elicited by a mechanical stimulus. A mechanical stimulus, such as the clinician touching the patient with their hands or an instrument, may be necessary to initiate the succession of neurophysiological responses which produce the desired effects of manual therapy.[15]

One of the possible reasons for changes in the periphery and not the central nervous system is the treatment was performed in the periphery. Chronic pain is effectively generated as a consequence of changes within the CNS. These alterations effect how the CNS responds to sensory inputs, rather than reflecting the presence of peripheral noxious stimuli.[24] Therefore, the target for the treatment in these situations should ultimately be the CNS, not the periphery.[24] Initial treatments in the periphery may be able to decrease pain in those areas and over time, aid in reversing the changes in the CNS. Also, the treatment may have only had a local effect due to the short duration. One 45 second treatment in that area may be enough for peripheral changes, but central changes will likely take a greater amount of time. Changes in the way the central nervous system processes pain occur over a long period of time, so an intervention attempting to reverse those changes is likely to take a longer amount of time as well.[24] Future longitudinal studies are needed to assess the treatment effect over time and to determine changes in central pain processing.

Some limitations of this study will need to be addressed by future research. We had 11 participants in the Fibromyalgia cohort and 8 in the healthy cohort, for a total of 19. With a small sample size, it is difficult to generalize these outcomes for the entire population. A larger sample size and a more balanced design would allow better power for group comparisons. Also, our intervention consisted of only one Graston technique light brushing treatment so we could only report an immediate effect. In order to determine chronic effects of the treatment, a prospective study would be needed with multiple treatment sessions. Despite these limitations, the GT light brushing technique demonstrated the ability to desensitize a painful area in patients with chronic pain. We do not know the effects of a full Graston technique treatment that would include an 8-10 minute treatment followed by exercises.

Chronic pain is an ongoing problem in our society; therefore any new effective treatment options may be extremely beneficial.[2] Fibromyalgia Syndrome is a chronic pain condition that affects many people across the country. Currently, there is no cure but different treatments and therapies are often used to help decrease the pain associated with FMS. The use of manual therapy has proven to be effective in decreasing pain and disability. The Graston Technique is an instrument assisted soft tissue mobilization technique and the "light brushing" stroke is proposed to desensitize the treatment area prior to more aggressive stages of the protocol. If the light brushing stroke is able to desensitize a painful area and therefore decrease pain, it may be a new treatment option for individuals suffering from Fibromyalgia and other chronic pain conditions. The treatment time is much shorter than other modalities used to decrease pain such as heat, ice or electrical stimulation, which makes it more efficient.[1]

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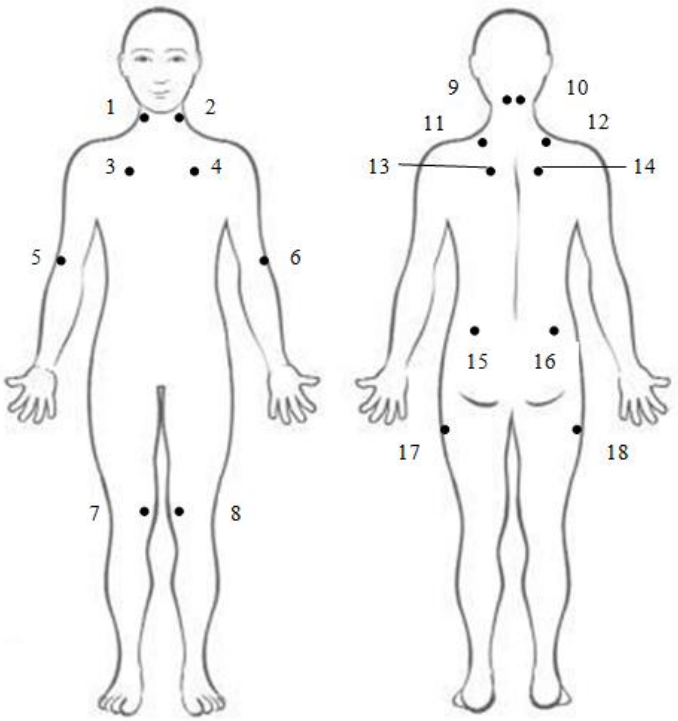
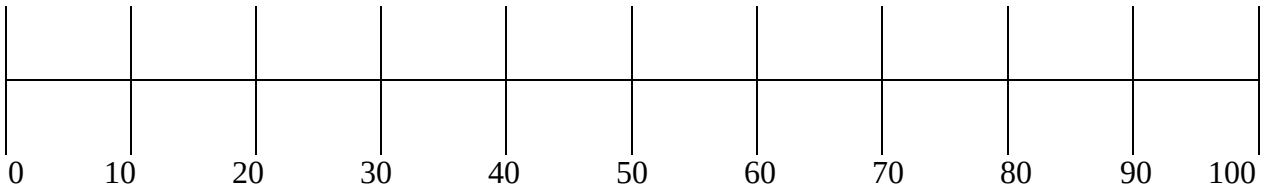
APPENDIX A: VISUAL ANALOG SCALE (VAS)

Subject ID #:_____





No Pain

Pain as bad as you can Imagine

Please identify your 3 most painful sites from the chat above and rate the pain at each point using the 0-100 scale.

	Point Number (1-18 from chart above)	Pain Rating (0-100)
Site A		
Site B		
Site C		

APPENDIX B: FIBROMYALGIA 18 POINTS