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Hemodynamic Effects of Graston Technique on Trigger Points in the Upper Trapezius in Patients with Neck Pain

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HEMODYNAMIC EFFECTS OF GRASTON TECHNIQUE ON TRIGGER POINTS IN THE

UPPER TRAPEZIUS IN PATIENTS WITH NECK PAIN

HANNAH HARRIS

56 Pages

Background: Non-specific neck pain (NS-NP) is defined as neck pain without a specific diagnosis with varying causes such as poor posture, occupational stressors, and muscular trigger points. Individuals often present with poor posture, including forward head and rounded shoulders. In this position, the upper trapezius muscle becomes tight due to sustained muscle activity leading to trigger points as a result of decreased oxygen to the muscle. Graston Technique® (GT) is a form of manual therapy that uses stainless steel instruments to break down tissue adhesions. GT on trigger points has been presumed to increase local blood flow leading to tissue healing and decreased pain, however, the physiological effects on muscle hemodynamics have yet to be proven.

Objective: To measure active cervical range of motion, neck pain, and subcutaneous hemodynamics of the upper trapezius following a single intervention of GT in patients with neck pain stemming from trigger points.

Participants: Sixty participants between the ages of 18-40 years old with NS-NP and trigger point(s) present in the upper trapezius muscle. Participants were excluded if they had manual therapy treatment within the past 3 months to the neck or shoulder area, history of a diagnosed neck injury, history of spinal or shoulder surgery, cancer, kidney dysfunction,

pregnancy, taking an anticoagulant medication, varicose veins, polyneuropathies, diabetes, heart failure, contagious skin conditions, open wounds, thrombophlebitis, and hypertension.

Methods: Participants were allocated into one of the following groups: GT, sham instrument assisted soft tissue mobilization (IASTM), or control. All participants completed the GT protocol which included: a 10-minute arm bike warm, 5-minute treatment based on group allocation, passive lateral flexion stretch, and 3 therapeutic exercises. Treatment area was determined by bilateral palpation of the upper trapezius muscle for the most prominent trigger point.

Results: There were increased levels of oxygenated hemoglobin at superficial and deep depths in the GT and sham groups ($p \leq 0.008$) compared to the control group. However, there were no differences found between GT and sham ($p \geq 0.555$). For ipsilateral lateral flexion, there was no treatment main effect ($p=0.126$), however GT showed increased ROM compared to control ($p=0.043$) with post-hoc testing. For contralateral lateral flexion, there was a main effect ($p=0.001$), where GT and sham showed increased ROM compared to the control, $p \leq 0.001$ and $p=0.019$, respectively. There were no differences among groups for PPT ($p=.201$).

Conclusion: Overall, GT proved to be an effective treatment technique on subcutaneous hemodynamics and ROM in the upper trapezius muscle in patients with neck pain. After a single treatment of GT, participants received increased blood flow to the upper trapezius and increased neck range of motion. Further research is needed to establish GT as a superior treatment to other forms of instrument assisted soft tissue mobilization.

KEYWORDS: blood flow, instrument assisted soft tissue mobilization (IASTM), manual therapy

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CHAPTER I: INTRODUCTION

The upper trapezius muscle is involved in many actions performed by the human body during everyday activities. It helps to stabilize and support the scapula when the arm is in an elevated position and keep the head in a neutral position for proper posture.[1] Previous studies have shown the upper trapezius muscle is activated for sustained periods during daily activities, such as sitting at a desk or looking at a cellphone.[1-4] Furthermore, the activities of daily living can affect the neck and shoulder musculature leading to changes in posture, such as Forward Head and Rounded Shoulders (FHRS).[1,3,5]

When the body is positioned in FHRS, the upper trapezius muscle activity is heightened, which leads to muscular imbalances.[2,3] These muscular imbalances often result in upper trapezius muscle tightness, trigger points, dysfunctional movement, and neck pain. There have been several studies that reported sustained upper trapezius muscle activity is related to the development and presence of neck pain.[2,4-7] Periods of sustained muscle activity create the spasm-pain-spasm cycle due to decreased blood flow, oxygen, and nutrient supply to the muscle.[5,8-12] Furthermore, the formation of myofascial trigger points results in pain, limited range of motion, and restricted functional movements. A previous study defines a myofascial trigger point as a hyperirritable point found within a taut band of skeletal muscle that becomes painful with compression, stretch, or stimulation that causes distant referred pain from the specific point.[14] Trigger points can be categorized as active or latent, where active trigger points are those causing consistent local and referred pain patterns and latent trigger points, although hyperirritable, do not cause pain until palpated.[5,9,10,13] Active and latent trigger points present in the upper trapezius muscles can play an important role in mechanical neck pain.[9,14] Non-specific neck pain (NS-NP), one of the top five leading chronic pain conditions, can be defined as

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mechanical neck pain without an identifiable diagnosis.[1,15–20] Patients experiencing NS-NP can result from varying causes such as poor posture, occupational stressors, and myofascial trigger points.[2,5,6,20–22]

In the past, trigger points in the upper trapezius muscle were treated using many different manual therapy techniques. Significant improvements on pain pressure threshold (PPT) and cervical spine range of motion (ROM) using cervical mobilizations and ischemic compression techniques have been found.[23] Concurrently, advanced manual therapy techniques like active release technique and muscle energy technique have proven to increase cervical ROM, decrease pain, and decrease the thickness of the upper trapezius muscle.[5] However, a manual therapy technique that is lacking research for the treatment of the upper trapezius muscle is the use of instrument assisted soft tissue mobilization (IASTM).

A manual therapy technique, IASTM uses instruments for the evaluation of soft tissue with the goal of enhancing myofascial mobility.[24–28] The physiologic effects on restricted tissue produced by IASTM have been well studied.[24,27,29–33] IASTM enhances proliferation of extracellular matrix fibroblasts, improves ion transportation, decreases cell matrix adhesions, and decreases tissue viscosity.[24–27,29,30] A type of IASTM, Graston Technique® (GT), uses stainless steel instruments that act similar to tuning forks by sending vibrations felt by the clinician to locate abnormal tissue properties.[25,26,31,34] GT goes beyond typical IASTM by adding stretching, strength exercises, and cryotherapy to its procedural protocol.[31] Additional benefits of GT include the perfusion of oxygen, nutrients, and blood and lymph flow to the treated area.[31] The available research that has studied the effects of GT on the upper trapezius have found improvements in pain pressure threshold and increased range of motion.[24,29] However, there is a need for further explanation of the effects of GT on the upper trapezius muscle hemodynamics.

The presence of active trigger points, a result of decreased oxygen, found in the upper trapezius muscle may be a large contributor to neck pain and limited range of motion as a result of decreased blood flow.[9,14,35] Therefore, the purpose of this research study was to measure active cervical ROM, neck pain, and subcutaneous hemodynamics of the upper trapezius following a single intervention of GT in patients with neck pain stemming from trigger points. We hypothesized that the GT treatment would cause immediate improvements on cervical ROM and neck pain and increase oxygenated hemoglobin to the upper trapezius muscle more than a sham treatment.

CHAPTER II: LITERATURE REVIEW

Anatomy

<u>Skin</u>

The largest organ of the body is skin, the integumentary system, which covers the entire body varying in thickness.[36–39] The skin is an organized, complex structure that functions to protect the body, regulate body temperature, sensory reception, aid metabolic functions, blood reservoir, and excretion.[39] The skin consists of three layers named the epidermis, dermis, and hypodermis.[36,39,40] The superficial layer, the epidermis, is made up of four to five layers of epithelial cells about 75 – 150 micrometers thick to act as a protective shield for the body.[36,39,41] The layers of the epidermis from deep to superficial are as follows: stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum.[36,39] Underlying the epidermal layer, the second layer of skin known as the dermis is approximately 1.5 -2.5 millimeters thick.[36,42] There are two layers of the dermis, which are the papillary and reticular layers.[39] The interrelated networks of the dermis act as the main load-bearing component in skin and is stiffer than the epidermis.[36,38] Lastly, the hypodermis as the third layer is not technically part of skin but has similar protective functions of shock absorption and insulation.[36,37,39] This layer has varying thickness throughout the body and anchors the skin to underlying tissues such as muscles.[36,39,40,43]

The skin is comprised of a complex variety of contents that differ in each layer to serve their specific functions. The epidermis consists of five types of cells: epithelial cells, keratinocytes, melanocytes, dendritic cells, and tactile cells.[39] The dermis consists of a vast community of cells, fibers, and tissues that makes up the tough, leathery layer. Dense irregular connective tissue creates the dermal layer and within consists collagen, elastin, ground

substance, reticular fibers, and extracellular matrix.[36,38,39,44,45] The dense irregular connective tissue is comprised of thick bundles of collagen fibers that provide high tensile strength and resiliency to skin.[36,38,39,46–48] Elastin fibers allow the skin to undergo deformation and recoil back to its original shape and size.[36,38,39,46–48] Ground substance, comprised of proteoglycans, lies between collagen and elastin fibers to act as a lubricant and an aid for collagen fiber formation.[38,47] The reticular fibers found in dense irregular connective tissue form elaborate branches around blood vessels and capillaries to support the tissue.[39] The extracellular matrix contains adipose cells and interlacing collagen fibers that run parallel with the skins surface.[39] The hypodermis consists of mostly adipose tissue to provide protection to underlying tissues.[39]

The contents of the skin layers work together to create the properties of skin. Previous research has established the properties of skin to be as follows: stress-strain, creep, elasticity, extensibility, viscoelasticity, anisotropy, and hysteresis.[36,38,40,46,49,50] The external forces applied to skin, known as stressors, can cause the tissue to change in length or deform, placing the skin on strain.[38,49] Elastin fibers dictate the recoiling mechanism after deformation of the skin.[36,40,46] Creep is simply the act of slowing deformation under stress by increasing the strain with straightened collagen fibers.[38,50] Elastin provides the elasticity property of skin by allowing the material to return to its original shape when forces are removed.[38] The extensibility of skin is the maximum strain that can be placed on the skin before permanent deformation occurs.[38] Viscoelasticity is the concept where skin deformation is temporary under short-term stresses, but permanent deformation occurs with sustained stress.[38] The skin has varying thickness, patterns, friction lines, and other differences that can classify the skin as anisotropic.[38,49] Due to properties such as viscoelasticity, the skin may go through hysteresis where a change in the skin caused by forces may not reverse such changes in the same amount when the force is removed.[38]

Collectively, the properties of the skin are due to the variety of components that make up the different layers of the skin.

Fascia

According to the American Heritage Stedman's Medical Dictionary, fascia is considered a sheet or band of fibrous connective tissue that envelops, separates, or binds together muscle, organs, and other soft tissue structures throughout the body.[51,52] Previous research has established fascia creates a continuous, tensegrity-like system throughout the entire body to provide body-wide links.[52–58] As fascia can be found throughout the body, the characteristics, thickness, contents, and adherence to muscle may differ depending on location.[53,59–61] Fascia is commonly thought to be made up of dense regular connective tissue with closely packed collagen fibers, elastin fibers, and hyaluronic acid.[31,39,62–64] These contents work to provide tension, flexibility, and gliding properties to fascial tissue.[31,39,62–64] According to Stecco et al.[52], between the skin and muscle there are three fascial layers which are the superficial fascia, deep fascia, and epimysium that all contribute to the characteristics of the tissue.

The first layer, superficial fascia, separates the skin from the musculoskeletal system to allow proper sliding between them.[31,52,62,63] The superficial fascia can be identified throughout the body as thicker in the lower extremities and posterior aspect.[31,52,61–63] Found within the superficial fascia are many free nerve endings, nociceptive fibers, adipose tissue, collagen fibers, and elastin fibers.[31,39,62,63] The superficial fascia adheres to the deep fascia on bony prominences and ligamentous folds.[52] The deep fascial layer is a well-organized, dense, fibrous membrane that forms an elaborate network which surrounds and separates muscles, forms sheaths for nerves and vessels, strengthens ligaments, and binds structures together.[31,52,62,63] Deep fascia consists of dense irregular connective tissue, free nerve endings like Ruffini and Pacini corpuscles, and

aponeurotic fascial tissue.[31,52,62,63,65,66] Lastly, the epimysial fascia, which is an extension of the deep fascia, tightly covers the muscles of the trunk.[31,62,63]

Previous studies provide important information on the roles and properties of fascia due to their contents and rich innervation. The most well-known role of fascia is the connection of muscle to the body.[32,53,67,68] In recent studies, the contractile cells, free nerve endings, mechanoreceptors, and nociceptors found in fascia allow for proprioceptive and nociceptive function.[31,53,59,62,63,69–75] These studies relate these roles to the etiology of musculoskeletal pain of the connected anatomical structures.[53,55,56] Other widely accepted roles of fascia include: aiding venous return, interactions among limb muscles, movement perception and coordination, protective sheets for underlying structures, support for subcutaneous structures, and integrity of skin.[52,60,76–86]

The literature suggests two main properties of fascia: stiffness and force transmission. Wilke et al.[32] described fascial stiffness as the resistance to external deformation by cellular contraction and fluid modification. When a mechanical stimulus is applied to fascia, the tissue responds with a "strain-hardening" effect with an initial decrease in stiffness and recovery of stiffness at rest.[32,87,88] Changes in water content influence the viscoelastic behavior of connective tissue thus manipulating fascial stiffness.[32,89–91] The stiffness of fascia offers the ability of force created by muscles to be transmitted through the tissue.[33,52,53,68,92–95] An estimated 30-40% of force generated by muscle is transmitted through the fascial tissues surrounding the muscle.[31,52,62,63,96] The myofascial transmission may act as protection to avoid overloading muscles but can contribute to musculoskeletal pain conditions.[32,54]

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<u>Muscle</u>

Muscles have the ability to transform chemical energy, adenosine triphosphate (ATP), into directed mechanical energy and produce force.[39] There are three types of muscle tissue: smooth, cardiac, and skeletal muscle.[39] Smooth muscle tissue is found in the walls of hollow visceral organs, stomach, urinary bladder, and respiratory passages and forces fluids and other substances through internal body channels.[39] Cardiac muscle tissue is found only in the heart which causes the rhythmic movement of blood throughout the body.[39] Skeletal muscle tissue is the most abundant muscle tissue found throughout the body as it creates the muscles of the body.[39]

Skeletal muscle cells can be distinguished by their elongated and striated appearance connective tissue sheaths, and voluntary control.[39] Also known as muscle fibers, skeletal muscle tissue is the only muscle type subject to the conscious control of the somatic nervous system as every muscle fiber is supplied with a nerve ending.[39] The three connective tissue sheaths: epimysium, perimysium, and endomysium provide continuous connections of the muscle itself and tendons that attach muscles to bone.[39] Typically, each muscle is served by one nerve, one artery, and one or more veins that enter or exit near the center of the muscle and branch through its connective tissue sheaths.[39] The functions of muscle include: movement production, posture and body position support, joint stabilization, and heat generation.[39] Properties of muscle tissue such as, excitability, contractility, extensibility, and elasticity set this tissue apart from the others. Excitability is defined as the ability of a cell to receive and respond to a stimulus by changing its membrane potential.[39] For example, neurotransmitters are released by nerves serving the muscle and elicit a response of the cell. Contractility, the ability to shorten forcibly when stimulated, can be the response of the cell to the neurotransmitter. Muscle contraction is possible as each muscle

is served by at least one motor nerve, which contains axons of numerous motor neurons that transmit action potentials through neuromuscular junctions.[28] As muscle contraction occurs the muscle cells shorten but they also have the ability to be stretched beyond their resting length when the skeletal muscle is relaxed, known as extensibility.[39] Also, the elasticity property of muscle cells allows the muscle to recoil and resume its resting length.[39]

The cervical musculature plays an important role in normal mobility and stability of the cervical spine.[97] The prime cervical flexor muscles include: sternocleidomastoid, anterior scalene, middle scalene, and posterior scalene. The sternocleidomastoid (SCM) muscle originates on the manubrium of the sternum and the medial one-third of the clavicle and inserts at the mastoid process and the lateral portion of the superior nuchal line of the occipital bone.[39,98] This muscle is innervated by the accessory nerve, or cranial nerve XI, and cervical spinal nerves C1 through C3.[98] The SCM bilaterally performs elevation of the rib cage and cervical flexion; whereas, unilaterally it rotates the cervical spine to the opposite side and laterally flexes the cervical spine to the same side.[39,98] The scalene muscles include three portions: anterior, middle, and posterior. All three perform the same actions of bilateral cervical flexion and elevation of the ribs during inhalation and unilateral cervical rotation to the opposite side and laterally flexing the cervical spine to the same side.[98] The anterior scalene originates from the transverse processes of C3 through C6, inserts at the first rib, and is innervated by cervical nerves C3 through C8.[39,98] The middle scalene has its origin on the transverse processes of C2 through C7 and its insertion at the first rib.[39,98] This muscle is innervated by cervical spinal nerves C3 through C8.[98] The posterior scalene originates from the transverse processes of C6 and C7 with its insertion on the second rib.[39,98] It is also innervated by cervical nerves C3 through C8.[98] The prime cervical extensor muscles include: splenius capitis, splenius cervicis, levator scapulae, and upper

trapezius. The splenius capitis has its origin on the inferior half of the ligamentum nuchae and the spinous processes of C7 through T4 with its insertion on the mastoid process, lateral portion of the superior nuchal line, and the occipital bone.[39,98] It is innervated by the cervical spinal nerves C1 through C8.[98] This muscle acts to bilaterally extend the cervical spine and unilaterally rotate and laterally flex the cervical spine to the same side.[39,98] The splenius cervicis muscle originates at the spinous processes of T3 through T6, inserts at the transverse processes of C1through C3, and innervated by the cervical nerves C1 through C8.[39,98] Bilaterally, this muscle causes cervical extension; whereas, unilaterally it causes cervical rotation and lateral flexion to the same side.[39,98] The levator scapulae originates from the transverse processes of C1 though C4 and inserts at the medial border of the scapula between the superior angle and the superior portion of the spine of the scapula.[39,98] This muscle is innervated by cervical nerves C3 through C5 and the dorsal scapular nerve.[98] It acts to bilaterally extend the cervical spine and unilaterally elevate the scapula, downwardly rotate the scapula, laterally flex and rotate the cervical spine to the same side.[39,98] The upper trapezius muscle has its origin at the external occipital protuberance, medial portion of the superior nuchal line, ligamentum nuchae, and the spinous processes of C7.[39,98] This muscle inserts at the lateral third of the clavicle, the acromion process, and the spine of the scapula and is innervated by the accessory nerve, or cranial nerve XI, and cervical spinal nerves C3 and C4.[39,98] Bilaterally, it performs cervical extension, and unilaterally performs upward rotation of the scapula, cervical rotation to the opposite side, and cervical lateral flexion to the same side.[39,98]

Bone

All bones perform seven important functions including: support, protection, anchorage, mineral and growth factor storage, blood cell formation, triglyceride fat storage, and hormone

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production.[39] The bones of the cervical spine work to support the head and provide attachment sites for muscles that move the neck. The cervical spine consists of seven vertebrae of different shapes and sizes that allow versatile movement while being the most mobile and least stable part of the spine.[15,99] Although the cervical vertebrae are different shapes and sizes, they possess a concave posteriorly curvature and are the smallest and lightest vertebrae in the spine.[39,98] The first two cervical vertebrae, C1 and C2, also known as the atlas and axis, can be differentiated from the remaining cervical vertebrae by their robust shape, absence of an intervertebral disc, and uniquely modified structures.[39] The atlas (C1) does not contain a body or spinous processes but is rather a ring of bone that consists of anterior and posterior arches and lateral masses that serve as articular facets.[39,98] The superior articular facets articulate with the occipital condyles, while the inferior articular facets form joints with the axis (C2) to allow flexion and extension motions at the cervical spine.[39] The axis does possess a vertebral body, spinous processes, and transverse processes but contains an unusual feature that projects posteriorly from the body, the dens.[39,98] The dens acts as the missing body of the atlas and fuses the two vertebrae to provide a pivot for rotation of the cervical spine.[39] The remaining cervical vertebrae C3 through C7 possess distinguishing features including: an oval shaped vertebral body, a short spinous processes that projects posteriorly and is bifid at its tip, a large, triangular shaped vertebral foramen, and a transverse foramen in each transverse processes to allow vertebral arteries to pass through to the brain.[39] The last cervical vertebrae, C7, does not have a bifid spinous process and is much larger than the other cervical vertebrae, which acts as a palpable bony landmark.[39,98] The cervical spine region between C3 and C7 has the greatest range of motion of the entire spine with cervical movements of flexion, extension, lateral flexion, and rotation.[39] Other bony landmarks that influence movement at the cervical spine include the thoracic vertebrae, lateral one-third of

the clavicle, the acromion process, and the scapula as they act as bony attachment sites for muscles.[39,98]

<u>Vasculature</u>

Vasculature refers to the supply of blood to specific regions of the body.[39] Concerning the skin, blood flow through the skin helps to supply nutrients to the cells which aids the regulation of body temperature and provides a blood reservoir for the body.[39] The epidermal layer is avascular, meaning no blood reaches the cells of this region, but is innervated by fibers and nourished by the substances that are diffused from blood vessels into the underlying connective tissue and dermal layer.[39] The dermal layer of skin has an extensive vascular supply and can hold up to 5% of the body's entire blood volume.[39] However, when the muscles need greater blood supply, the nervous system constricts the dermal blood vessels to push more blood into circulation allowing blood to be more available to the muscles.[39] The underlying fascial layers are supported by arteries, veins, and lymphatic vessels.[31,39,62,63]

The skeletal muscles have a rich blood supply with muscle capillaries being the smallest of the body's blood vessels that stretch long and wing to create numerous cross-links that accommodate changes in muscle length.[39] Due to the contracting muscle fibers, large amounts of energy are required to supply continuous oxygen and nutrients via the arteries.[39] Although blood flow in skeletal muscle varies with fiber type and muscle activity, resting muscles receive about one liter of blood per minute with only about 25% of their capillaries open.[39] On the other hand, when muscles are physically active the sympathetic nervous system causes vasoconstriction of vessels of the digestive system and skin to increase blood flow in direct proportion to the greater metabolic activity as all capillaries of the active muscles are opened.[39]

Non-Specific Neck Pain

Definition

Neck pain is a common musculoskeletal disorder that can cause varying levels of disability and is considered one of the top five leading chronic pain conditions.[1,15–20,100,101] There is a high prevalence of neck pain among occupational sectors, middle aged people, and women.[1,15,18] Previous research has estimated about two-thirds of people will experience neck pain at some point in their lives.[6,15,16,18,20,101,102] The prevalence of neck pain being so high imposes considerable personal and socioeconomic burden on those individuals affected by this musculoskeletal disorder.[17,20,103–105]

Each individual may experience different neck pain symptoms, so the term nonspecific neck pain (NS-NP) has been established to group individuals with neck pain. NS-NP is used as a classification for patients experiencing neck pain without an identifiable disease, abnormal anatomical structure, or specific cause.[17,20] This pain disorder is typically diagnosed on clinical grounds alone when there are no red flag features to suggest more serious conditions.[15,97,106] Previous studies on NS-NP define the condition as neck pain with a mechanical or postural basis, which includes pain following whiplash injury without bony or neurological injury but does not include fibromyalgia pain.[15–17,107] Binder et al.[15] stated that NS-NP typically resolves within days or weeks, but can reoccur and become chronic. Symptoms associated with NS-NP often occur in combination with limited movement and poorly defined neurological symptoms affecting the upper limbs.[16] Typical signs and symptoms include: sensitivity, fatigue, stiffness of neck and shoulder muscles, radiating pain to the occiput, neck, shoulders, and upper limbs, weakness, headache, and limited cervical range of motion.[15–17,108,109]

<u>Causes</u>

As mentioned, there is no specific, identifiable underlying cause of NS-NP but previous literature has identified risk factors, postural basis, mechanical basis, and soft tissue involvement that can be related to the disorder. Generally accepted risk factors that may predispose an individual to neck pain include poor posture, anxiety and depression, neck strain, occupational or sporting activities, genetics, sleep problems, obesity, sedentary lifestyle, trauma, back pain, and general poor health.[15,16,20,110–113] Although there is an understanding of the risk factors that contribute to NS-NP, each individual presents differently as the cause is multifactorial.[15]

Poor posture can be defined as an increased forward head, increased thoracic kyphosis, and a more anterior shoulder position.[7] Occupations such as computer workers, manual laborers, healthcare workers, and drivers are specifically prone to this poor posture that can lead to an imbalance in muscular pattern, reduce epidemiological function of the body, and weakens soft tissues.[2,5,20,21] Previous studies have associated sustained awkward postures with a long-term low intensity stimulus and activity of the upper trapezius, a prime cervical muscle.[3–5] Concurrently, Nicoletti et al.[6] reported sustained upper trapezius muscle activity directly correlates with the presence and may predict the development of neck pain.

Previous literature suggests that weakness or fatigue of neck muscles, specifically the deep cervical flexors and deep extensors of the cervical spine, are related to neck pain as about 80% of spinal stability is based on muscular activity.[97,114–119] The reduced muscle activity, such as in the upper trapezius, leads to the spasm-pain-spasm cycle which decreases blood, oxygen, and nutrient supply to the muscle further leads to the formation of myofascial trigger points.[5] Chiarotto et al.[22] found the prevalence of active trigger points ranged from 14.8% in the levator scapulae to 38.5% in the upper trapezius muscles in people with neck pain.[20] Other previous

studies found a relationship between decreased myoelectric activity of trigger points with muscle weakness and increased myoelectric activity of trigger points with muscle stiffness, spasms, and irritable muscles.[20,120–122] The fascia connecting muscles may also be affected and lead to myofascial pain, a common cause of neck pain.[20,123] Myofascial pain involves discrete and diffuse areas of sensitivity within one or more muscles as a result of sustained muscle contractions, local ischemia, and muscle fiber shortening.[20,123] Overall, soft tissue injury is considered the most likely mechanical explanation for NS-NP symptoms.[15]

<u>Current Treatments</u>

As NS-NP does not have a clear cause, the treatment plan is often based on the clinical findings of an evaluation by a clinician.[97,119] Although there is still no consensus on the best form of treatment for NS-NP, previous studies found improvement using a combination of treatment types.[11,15,17,20] The goal of treatment should include correcting any underlying structural and postural imbalances.[11,20] Among the evidence for treatments, therapeutic exercise has the strongest evidence when combined with manual therapy, while alternative treatments and medication do not have as strong of evidence but are still accepted.[15,17,20,124–133]

Manual therapy treatment of NS-NP includes massage, mobilizations, manipulations, stretching, myofascial release therapy, and dry needling techniques.[5,15,17,20] Previous studies have found great improvements on NS-NP using techniques such as these. Myofascial release therapies such as, active release technique, muscle energy technique, strain-counter strain, and ischemic compression, have been proven to decrease neck pain, increase cervical range of motion, improve pain pressure threshold, and improve neck disability index scores.[5,23,134,135] Simple manual therapy techniques like stretching and massaging have been found to improve cervical range of motion and pain pressure threshold in patients with NS-NP.[136,137] On the other

hand, a less common form of manual therapy, dry needling, has been recommended in the treatment of neck pain as it can improve pain pressure threshold, improve neck disability index scores, and decrease pain.[134,135,138] Cervical manipulations and mobilizations have limited evidence but have proven effective in reducing pain, improving range of motion, and improving pain pressure threshold in comparison to other treatment options.[15,16,23,100,130,131,136,139–143]

Therapeutic exercise is the basis for most treatment plans of people experiencing NS-NP because of the emphasis on reestablishing cervical muscle functions.[17] Binder et al.[15] established the implementation of exercise programs is more effective than usual care of neck pain.[100,127,128,144–146] The use of exercise strengthening programs alone in the treatment of NS-NP can reduce pain but has been found more effective when in combination with manual therapies like, manipulations and mobilizations.[15] Cohen et al.[20] stated that therapeutic exercise can be beneficial for neck pain by stimulating endorphin secretion, which can help to improve sleep, mood, and prevent deconditioning of muscles.

Alternative treatments include a vast variety of non-traditional approaches to musculoskeletal disorders. The range of treatment types include acupuncture, cupping, yoga, meditation, and stress management.[15,20,147–149] Previous studies found after a session of acupuncture, patients with NS-NP experience a decrease in pain and improve their quality of life.[16,17] Although the therapeutic effects of treatments such as yoga, stress management, and meditation have not been thoroughly assessed, they have been shown to aid in the improvement of neck posture.[15]

Medications such as, non-steroidal anti-inflammatory drugs (NSAID), analgesics, muscle relaxants, and anti-depressants are commonly used to treat NS-NP.[16] Hsieh et al.[150] and Predel et al.[151] established benefits of using a topical NSAID in people with neck pain, which is consistent

with more recent literature stating the efficacy of topical NSAIDs.[20,152] Although the use of

analgesics, NSAIDs, and antidepressants are used empirically in the treatment of NS-NP, there is

still not strong enough evidence to determine their efficacy.[16]

Instrument Assisted Soft Tissue Mobilization

Definition

Instrument assisted soft tissue mobilization (IASTM) is a technique used to treat

musculoskeletal pathologies by mobilizing the injured soft tissue using different

instruments.[27,31,63,153–155] There are different forms of IASTM including: gua sha, Graston

Technique®, sound-assisted instrumentation, and fascial abrasion.[27,153,155–157] IASTM is used to

help remove scar tissue and promotes soft tissue to return to its normal functions.[27,158–160] This is

achieved by scraping the skin with an instrument to bring blood flow and oxygen to the

underlying tissues to facilitate the healing process.[27,156,161] The use of IASTM on soft tissue

works to inhibit tissue restrictions by stimulating the repair and realignment of collagen, an

extracellular matrix protein.[19,20,23,25,26,156,158,162–164] The fibroblasts found in the extracellular

matrix have been shown to increase in number after the use of IASTM, which aids connective

tissue remodeling.[24,26,27,29–31,63,158,162–164] Additionally, IASTM restores the natural gliding and

proper lubrication between tissue layers.[27,31] Previous studies have justified the use of IASTM

for pathologies such as: chronic fibrosis, lateral epicondylitis, carpal tunnel syndrome, trigger

thumb, plantar fasciitis, patellar tendonitis, achilles tendonitis, and lumbar

pain.[25,28,29,154,159,160,165–170]

Benefits

Implementing IASTM as a treatment for soft tissue pathologies is simple, practical, and

provides benefits to the clinician, patient, and musculoskeletal pathology.[27,171] For the clinician,

using IASTM allows for better detection of altered tissue with a mechanical advantage from the instrument.[26] The vibrations felt through the instruments being used alert the clinician of tissue changes while allowing deeper penetration and more specific treatment to the tissue.[26] IASTM treatment time is much shorter when compared to a traditional friction massage, which benefits the clinician and patient.[27] Additionally, the use of IASTM in treatment has been shown to decrease overall rehabilitation time and return the patient back to physical activities faster.[27] This can be achieved as IASTM has been found efficient in reducing pain, improving range of motion, and improving function.[26,27,172,173]

Graston Technique

Background

Graston technique® therapy (GT), a form of IASTM, was created in 1994 by clinical personnel and university researchers to create a more efficient manual therapy application.[31] The researchers designed GT to give clinical practitioners a unique alternative modality for the benefit of patients.[31] This evidence-based form of IASTM incorporates six specially designed stainless-steel instruments with beveled edges to enhance the clinician's ability to detect and treat soft tissue dysfunctions.[25,31] GT generates mechanical micro-traumatic damage to the area being treated to create an inflammatory response that accelerates the healing process and restores more flexible tissue.[30] The promotion of proper fiber alignment can only be achieved if the GT treatment is combined with stretching and rehabilitative strengthening exercises.[31] Although this technique is a type of IASTM, it can be distinguished by its registered trademarks and protocol for use.[31] The creators of GT ensure that only clinicians who have been trained by an authorized Graston Technique, LLC certified instructor using Graston technique brand instruments can represent themselves as performing Graston technique therapy.[31]

The GT protocol for treatment includes the following components: examination, warm-up, IASTM treatment strokes, post-treatment stretching, strengthening, and possibly cryotherapy.[26,31] The Graston technique brand instruments must be used as they help to locate remote myofascial strain patterns and amplify the tactile feel of soft tissue restrictions.[31] Instruments are applied to the skin in multidirectional, unique strokes at a thirty-degree to sixty-degree angle to ensure the undulation of the instruments detect and treat soft tissue irregularities.[24,29,162] A list of the clinical indications for the use of GT follows: tendinopathies, fascial syndromes, myofascial pain syndromes, ligament pain syndromes, edema reduction, scar tissue/adhesions, entrapment syndromes, and secondary soft tissue lesions associated with other diagnoses.[31] Clinicians need to keep in mind the relative contraindications of GT like, burn scars, pregnancy, autoimmune disorders, diabetes, acute inflammation, skin conditions, and others.[31] However, if a patient presents with any of the following, it is an absolute contraindication for GT use: open wounds, unhealed suture sites, sutures, thrombophlebitis, uncontrolled hypertension, inflammatory conditions due to infection, unstable fractures, hypersensitivity/intolerance of GT, contagious or infectious skin conditions, hematoma, myositis ossificans, osteomyelitis, insect bite of unexplained origin.[31]

Theories

Similar to IASTM, GT therapy has been purported to decrease cell matrix adhesions, remove tissue adhesions, release fascial restrictions, and break down cross-fiber links caused by soft tissue dysfunctions.[24,29–31,162,174–187] By using the GT brand instruments to release these restrictions, motion is restored to fascia and muscle tissue.[31,62,63] At the cellular level, previous studies have shown GT therapy can improve ion transport, enhance proliferation of fibroblasts, and promote collagen synthesis.[24,29–31,62,63,162] The Graston Technique M1 Training Manual states

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the physiological effects of GT therapy are as follows: increased fibroblastic activity, enhanced

blood perfusion, increased stem cells, Pizoelectric effect, Davis' law, altered neural activity, and

mechanotransduction.[31,171,188] Additionally, the increased tissue temperature caused by the

friction of the instruments stimulates blood, nutrients, and lymph to rush to the treated area and

increases circulation to enhance the healing process.[29,31]

    <u>Benefits</u>

    Previous research has shown the benefits of Graston technique therapy include aiding the

clinician, patient rehabilitation, and treatment outcomes. The GT instruments provide a

mechanical advantage for the clinician that allows less pressure and energy to be used while

increasing the depth of treatable tissue.[31] Promoters of GT claim the instruments do not compress

tissue, so the superficial fascial layer is easily mobilized to make deeper restrictions more

accessible.[31,34] An additional benefit of the GT brand instruments is the variety of shapes and

sizes of the six different instruments. The smaller edges found on specific GT instruments are

able to separate fibers and outline anatomy in an effective manner.[31] As GT therapy has proven

to be immensely effective, the total treatment time decreases and returns the patient to function

much faster than other forms of manual therapy.[31] There are various levels of evidence that

suggest GT reduces pain, improves range of motion, and improves overall function.[26,172,173]

Previous studies have found GT as an effective treatment for the following pathologies: lateral

epicondylitis, carpal tunnel syndrome, hamstring tendinopathy, low back pain, plantar fasciitis,

achilles tendinopathy, trigger finger, peroneal tendonitis, quadriceps tear, DeQuervain's

tenosynovitis, chronic calf pain, and tibialis posterior strain.[28,31,162,167,189–199] GT therapy not only

aids the rehabilitation of specific pathologies but can also can be used to improve pain pressure

threshold of trigger points, improve shoulder, lumbar spine, hip, and ankle range of motion,

increase hamstring and iliotibial band flexibility, and improve grip strength.[26,28–30,200–202]

Side Effects

The principle of GT therapy is to enhance myofascial mobility with limited adverse

effects, but patients may experience side effects if GT protocol is not followed correctly. For

example, when GT therapy is applied in excess the patient's condition may exacerbate.[31]

Clinicians using GT should avoid using too many treatment modalities, treating one specific

restriction for too long, using GT therapy too long during a single session, and using excessive

pressure.[31] When GT is used incorrectly a patient may experience discomfort, petechia, bruising,

or fear of GT treatment.[26,31]

Near Infrared Spectroscopy

Background

Near Infrared Spectroscopy (NIRS) was originally developed as a non-invasive method

for investigating the oxygenation of brain tissue.[203,204] Chance et al.[205] first applied NIRS

technology to study exercising skeletal muscle in humans in 1985.[206] Today, NIRS is an evolving

technology that allows a safe, non-invasive method to explore the characteristics of muscle tissue

among others.[207–209] Crenshaw et al.[204] explains the principle of differential absorption properties

of oxygenated and deoxygenated hemoglobin in the near-infrared range of the light spectrum to

assess skeletal muscle oxygenation as the basis for NIRS technology. Previous studies

established wavelengths between 600 to 900 nanometers is scattered and is absorbed by

hemoglobin and provide an index for deoxygenation.[209,210] Near infrared light can propagate

through tissues and is absorbed by the hemoglobin and myoglobin found in muscle, but the

refracted light not absorbed is used to measure the relative changes in oxygen consumption and

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delivery within muscle tissue.[203–205,209–212] A probe or NIRS device is placed onto the skin that enables the monitoring of signals from small vessels like arterioles, capillaries, and venules deep within the muscle.[204] Sako et al.[206] stated the parameters commonly measured by NIRS are as follows: oxyhemoglobin/myoglobin (Hb/MbO2), deoxyhemoglobin/ myoglobin (Hb/MbR), and total hemoglobin/myoglobin (THb/Mb). Previous studies have established NIR technology as a useful non-invasive method for monitoring muscle hemodynamics.[210]

Benefits

The major benefit of NIRS technology is the non-invasive application in clinical and research settings. A non-invasive method translates to a technique that can be applied to humans without discomfort or risk, repeatedly.[210,213] Additionally, the NIRS devices are practical and easy to use while being inexpensive in comparison to other methods like magnetic resonance spectroscopy.[208,209,213,214] Previous studies have established the efficacy, validity, reliability, and reproducibility of using the NIRS technology to monitor muscle hemodynamics.[204,206,209,210,214,215] NIRS can measure various aspects of skeletal physiology of a resting muscle and exercising muscle.[206,209,214,215] Mancini et al.[210] and Hampson et al.[216] confirmed NIRS measurements are not influenced by skin blood flow as skin temperature rises with maximal exercise. The aspects of skeletal muscle physiology that can be measured by NIRS includes oxidative metabolism, skeletal muscle blood flow, skeletal muscle oxygen consumption, and changes in muscle blood volume.[204,206,209,214,215,217–221] In clinical and research settings, there is an increasing interest to use the NIRS method to study the hemodynamics of different skeletal muscles.[208,209] Previous studies have used NIRS technology on the vastus lateralis, forearm muscles, gastrocnemius-soleus complex, and the upper trapezius.[204,209,210,213,214,216,217,219–233] As

NIRS technology continues to evolve, more muscles will be able to be monitored and more information on skeletal muscle hemodynamics will emerge.

CHAPTER III: METHODS

Study Design

This was a single blinded, controlled laboratory research study with randomization, utilizing GT on active trigger points found in the upper trapezius muscle. The independent variables were treatment group (control, GT, or IASTM) and time (baseline, immediate post-intervention, and 24 hours post-intervention). The dependent variables were neck ROM, PPT, and subcutaneous tissue hemodynamics (superficial and deep oxygenated, deoxygenated, and total hemoglobin). Hemodynamics were only measured at baseline and immediate post-intervention

Participants

Sixty participants with self-reported neck pain volunteered to participate in this study (Table 1). Inclusion criteria was the presence of trigger points in the upper trapezius muscle and NS-NP experienced within the last three months. Exclusion criteria was previous history of a diagnosed neck injury, history of spinal or shoulder surgery, cancer, kidney dysfunction, pregnancy, taking an anticoagulant medication, varicose veins, polyneuropathies, diabetes, heart failure, contagious skin conditions, open wounds, thrombophlebitis, and hypertension. Participants were informed of the procedures, risks, and benefits of participating in this research study and signed an informed consent form prior to participation. This study was approved by the Institutional Review Board at Illinois State University.

Table 1. Participant Demographics

Variable	Age	Sex	Height (cm)	Weight (kg)	Treatment Side
GT N=20	21.8 ± 2.9	Male = 10 Female = 10	172.6 ± 12.9	76.3 ± 14.9	Right = 14 Left = 6
IASTM Sham N=20	20.7 ± 1.6	Male = 5 Female = 15	168.5 ± 9.4	73.1 ± 16.4	Right = 13 Left = 7
Control N=20	22.2 ± 4.6	Male = 6 Female = 14	168.7 ± 9.4	73.5 ± 16.8	Right = 13 Left = 7

Instrumentation

The cervical spine ROM for lateral flexion was measured using a tape measure. Previous research established using a tape-measure for cervical ROM to have good to very good intra-reliability and inter-reliability and possess excellent correlation to goniometry measurements.[234–237]

A pressure algometer (Lafayette Manual Muscle Test System™, Model 01163) was used to measure the pain pressure threshold (PPT) and sensitivity of a specific trigger point site. Previous research has established pressure algometry to be useful in the evaluation of pain, diagnosis, and management of trigger points present in the upper trapezius muscle.[238–244] Concurrently, this method is a valid and reliable tool used in research studying myofascial adhesions and trigger points.[239,245–249]

The upper trapezius muscle hemodynamics were measured using Near-Infrared Spectroscopy (NIRS) (PortaMon™ Artinis Medical Systems). NIRS was first used in a 1997 study to demonstrate its application on human skeletal muscle.[203] Concentration changes were gathered at a sample rate of 10 Hz for 2 minutes. Light absorbance at 763 nm and 845 nm allowed for the calculation of superficial and deep hemodynamics utilizing the modified Lambert-Beer Law. Light transmitting optodes were located at 30, 35, and 40 mm from the

receiver allowing for light penetration between 15 and 20mm.[203–213,217,218,220,221] Values for oxygenated, deoxygenated, and total hemoglobin were reported in micromolar units (µM). The use of continuous-wave NIRS devices to measure skeletal muscle hemodynamics has a vast amount of previous research that have established the reliability, validity, and reproducibility of the technique.[204,206,209,210,213,214] Crenshaw et al.[204] concluded NIRS to have high reliability and reproducibility when assessing day-to-day measurements of the upper trapezius muscle.

Intervention

GT Group

The GT intervention group followed the GT protocol by completing an examination of soft tissue, warm up, instrument treatment, passive stretching, and strengthening exercises.[26,27,31] First, the investigator of this study who is a certified athletic trainer and GT certified, palpated all participants to locate trigger points present in the upper trapezius muscles. The most prominent (painful) trigger point, regardless if identified as a latent or active, was marked with an "X" to indicate the treatment side. Next, participants completed a ten-minute warm up using an arm bike. Following the warm-up, GT was used to treat the marked trigger point and surrounding tissues for a total of five minutes. Treatment included the use of GT instruments: GT1 and GT4 using different strokes. In order to prepare the participant's tissue, the clinician performed a GT sweeping stroke with light intensity using the GT1 instrument for one minute. Then, the tissue surrounding the trigger point was treated with GT4 using a fanning stroke for two minutes. Finally, the marked trigger points were treated with the knob of GT1 using a swivel stroke for two minutes (Figure 1). The implementation of these strokes were based on previous research that has established sweeping and fanning strokes increase circulation to the treated area and swivel strokes reduce tissue stiffness.[24,29,31] The participant was seated in an upright position

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with the arms resting at the thighs while the instruments were applied using multi-directional

strokes at a thirty to sixty-degree angle to enhance the physiologic effects.[24,31,162]

Figure 1. GT Instrument Application: GT strokes applied to the upper trapezius muscle in the following order: Sweep using GT1, Fan using GT4, and Swivel using GT1

Next, the clinician performed a passive stretch for lateral flexion contralateral to the treatment

side (Figure 2). Lastly, the participants were instructed on how to properly perform the following

strengthening exercises: shoulder shrugs, shoulder flexion, and shoulder press (Figure 3). These

exercises were chosen because they are commonly referenced in rehabilitation literature for

increased upper trapezius muscle activity.[250–254] Schory et al.[250] analyzed multiple studies to

identify higher upper trapezius activity performed in a standing position. Shoulder shrugs were

completed as the participant lifted both shoulders upwards towards the ears.[251,252] The shoulder

flexion exercise was performed with the forearms in a neutral position with the thumbs pointed

up as the participant completed full active shoulder flexion ROM.[250,253] The shoulder press

exercise was completed with the participants starting with the elbow and shoulder flexed at

ninety degrees followed by completing shoulder flexion ROM and elbow extension to raise the

arms above the head.[254] All three strengthening exercises were completed in three sets of six

repetitions. Kim et al.27 explains that the inclusion of strengthening exercises after IASTM

application enhances the realignment of collagen.

Figure 2. Lateral Flexion Stretch: Patient seated with arms relaxed as clinician stabilizes affected shoulder and laterally flexes the neck to the contralateral side.

Figure 3. Strengthening Exercises: Participant completed shoulder shrugs, shoulder flexion (posterior view), and shoulder press (start to finish in anterior view), respectively.

IASTM Group

The IASTM intervention group completed the GT group protocol but received a different

soft tissue mobilization tool as treatment to the upper trapezius trigger points. A generic IASTM

tool (Fibroblaster™) was used as a sham treatment for the participants in this group. The

participant was seated in an upright position with the arms resting on the thighs while the

clinician applied a sweeping stroke to the suspected trigger points and surrounding tissue of the

upper trapezius muscle for the allocated five-minute treatment time (Figure 4). After the

application of IASTM treatment, the participants in this group received passive stretching and completed strengthening exercises.

Figure 4. IASTM Sham Application: IASTM tool (Fibroblaster™) application on the upper trapezius muscle.

Control Group

The control group participants completed the GT protocol without the application of instrument treatment. After completing a warm-up, participants waited the allocated five-minute treatment time before concluding the protocol with passive stretching and strengthening exercises.

Procedures

All participants were randomly allocated into control, GT, or IASTM groups prior to the start of the intervention period. The participants, regardless of group assignment, followed the GT protocol including a ten-minute warm up, instrument treatment, passive stretching, and strengthening exercises.[26,27,31] This sequence of events was followed by an immediate measurement of active cervical ROM, pain, and muscular hemodynamics of the upper trapezius.

Another clinician, blinded to group allocation and trained in how to perform the measurements, measured the dependent variables at pre-intervention and immediate post-

intervention. Twenty-four hours post-intervention, the same clinician measured cervical ROM and pain. Cervical lateral flexion ROM was measured by a tape measure in centimeters from the earlobe to the acromion process and compared bilaterally. Pain was measured using the pressure algometer placed on the marked location of the most prominent trigger point found in the upper trapezius muscle for PPT. Measurement of PPT was performed three times and the average was recorded. The participant was seated upright on a chair with a backrest to support the thoracic spine and arms relaxed on the thighs for ROM and PPT measures. Subcutaneous hemodynamics were measured by a NIRS device placed parallel with the upper trapezius fibers around the site of the marked trigger point, secured with adhesive tape, and covered with a dark-colored cloth to restrict ambient light interference. The participant was prone on a treatment table with the arms relaxed by their side. All NIRS measurements were taken with the participant at rest with light intensity wavelengths at 800mm for a total of two minutes.

Data Analysis

One participant from each group was removed from data analysis due to the NIRS device not recording any data. For hemodynamics, change scores were calculated by subtracting the baseline measure from the immediate post-intervention measure. Separate one-way ANOVAs were used to assess oxygenated, deoxygenated, and total hemoglobin at two depths across groups. For ROM and PPT, separate repeated measures ANCOVAs, with the baseline value as the covariate, were used to assess differences at immediate post and 24 hours post-intervention across groups. Alpha level was set a priori at $p \leq 0.05$. Statistical analyses were performed using SPSS (IBM SPSS Statistics for Windows, version 25.0; IB< Corp, Armonk NY).

CHAPTER IV: RESULTS

Regarding hemodynamics, there were significant differences between intervention groups with changes in superficial and deep oxygenated and total hemoglobin ($p \leq 0.05$). Post-hoc tests revealed that the GT and Sham interventions had increased levels compared to the control group ($p \leq 0.008$) indicating increased blood flow. There were no differences between GT and Sham ($p \geq .555$) (Table 2).

Table 2. Hemodynamics Change Scores Immediate Post - Baseline

Variable	Superficial Oxygenated	Superficial Deoxygenated	Superficial Total Hemoglobin	Deep Oxygenated	Deep Deoxygenated	Deep Total Hemoglobin
GT	19.5 ± 13.5	3.0 ± 6.8	22.5 ± 18.9	17.2 ± 12.3	1.7 ± 6.2	19.3 ± 16.3
Sham	19.6 ± 16.3	3.1 ± 6.8	22.7 ± 21.8	19.8 ± 13.8	2.4 ± 6.3	22.1 ± 17.5
Control	-1.5 ± 14.2	0.3 ± 11.8	-2.2 ± 25.7	-0.5 ± 14.2	1.0 ± 13.1	0.5 ± 26.6
Effect Size GT:Control	1.52 (0.78-2.26)		1.10 (0.40-1.81)	1.61 (086-2.36)		0.86 (0.18-1.55)
Effect Size Sham:Control	1.37 (0.65-2.10)		1.05 (0.35-1.75)	1.40 (0.67-2.12)		0.97 (0.28-1.66)

For ROM and PPT, separate repeated measures ANCOVAs, with the baseline score as the covariate, were used to assess differences among groups at immediate post and 24 hours post-intervention. For ipsilateral lateral flexion, there was no treatment main effect ($p=0.126$), however, GT showed increased ROM compared to the control ($p=0.043$) with post-hoc testing. For contralateral lateral flexion, there was a treatment main effect ($p=0.001$), where GT and sham showed increased ROM compared to the control, $p \leq 0.001$ and $p=0.019$, respectively. There were no differences among groups for PPT ($p=0.201$) (Table 3).

Table 3. ROM (cm) and PPT (kg) Scores

Variable	GT	Sham	Control
Contralateral Lateral Flexion Baseline	9.90 ± 2.30	10.05 ± 3.22	9.71 ± 2.44
Contralateral Lateral Flexion Immediate Post	8.34 ± 2.21	9.13 ± 2.95	9.62 ± 1.96
Contralateral Lateral Flexion Post 24 hours	7.94 ± 2.51	8.66 ± 2.88	9.40 ± 2.28
Ipsilateral Lateral Flexion Baseline	9.13 ± 2.89	9.69 ± 2.98	9.57 ± 2.52
Ipsilateral Lateral Flexion Immediate Post	8.14 ± 2.59	9.16 ± 2.73	9.27 ± 2.59
Ipsilateral Lateral Flexion Post 24 hours	8.13 ± 2.28	8.87 ± 2.95	9.17 ± 2.41
PPT Baseline	8.23 ± 2.85	7.52 ± 1.75	7.95 ± 2.53
PPT Immediate Post	8.25 ± 2.91	7.03 ± 1.52	7.48 ± 2.52
PPT Post 24 hours	7.73 ± 3.18	6.52 ± 1.12	7.46 ± 2.34

CHAPTER V: DISCUSSION

After completing a single treatment following the GT Protocol, the results of this study concluded GT instruments and an IASTM tool increased oxygenated hemoglobin, indicating increased blood flow immediately following treatment. There was an overall increase in ROM following GT for both contralateral and ipsilateral neck lateral flexion. Also, the IASTM sham intervention showed increases with contralateral neck lateral flexion. However, there were no differences in pain reduction measured by PPT across all participants. While the sham and GT increased blood flow to the treatment area, it is important to note the results in ROM had better outcomes from GT compared to a sham instrument. Although the results of this study did not show GT instruments as a superior treatment overall compared to an IASTM tool, the effects of both treatment tools provided benefits to those with NS-NP. In previous research, NS-NP patients presenting with trigger points in the upper trapezius muscle have been established as a result of a lack of blood flow to the muscle.[5,6,8–12,14,20,31,35,255] Although research is limited on examining the direct effects of GT instrument on blood flow to the neck musculature, it has been proposed these instruments combined with specific strokes and standardized protocol, increases the rate and amount of blood flow to a treatment area more effectively than other IASTM tools.[31] As shown by the results of this study, the use of an IASTM tool and GT instruments significantly increased the amount of blood flow perfusing the neck musculature, which may lead to the breakdown of trigger points. However, there is a need for further research to examine the effects on blood flow between different types of IASTM tools on the upper trapezius.

There is an immense amount of literature on the use of IASTM tools, including GT, that have proven to significantly decrease pain and improve ROM in numerous areas of the body.[24,26–28,30,31,256] However, the literature presents pain in subjective and objective manners,

including the use of a Visual Analog Scale (VAS) and PPT, respectively.[24,28–31,172] Previous research on GT has shown significant decreases in VAS scores for patients suffering from low back pain, lateral ankle sprains, shoulder impingement, and cervical pain. [28,30,172] Lambert et al.[172] describes a study that examined the effects of IASTM on cervical pain and showed a decrease in pain using the subjective measure of VAS. Current literature has also suggested different forms of IASTM, including GT, can significantly improve PPT in patients presenting with neck pain and trigger points in the upper trapezius.[24,29,31,200] Miller et al.[200] found significant increases in PPT values to objectively measure the sensitivity of upper trapezius trigger points with the application of GT. In this study, participants in the IASTM and GT group did not show a significant decrease in pain after a single treatment when compared to a control group. However, all participants in this study went through the GT protocol and only received one, five-minute IASTM treatment, which may have altered the results. A previous study by Gulick et al.[24] found GT improved PPT on trigger points over a three-week period including six sessions. Also, PPT has been established as a valid and reliable measure of pain in trigger points[238–249] but may not translate after a single treatment of IASTM application. Due to increased petechiae and tenderness over the treatment area, it is common for patients to experience increased pain following a single treatment [26,31,256] Therefore, a twenty-four hour post-intervention measure may not allow enough time for pain reduction to be identified. The results of this study showed an immediate increase in ipsilateral cervical lateral flexion ROM after GT and an increase in contralateral lateral flexion ROM after GT and sham instrument application. There is high level evidence that suggests there are significant improvements in ROM after using IASTM as a treatment insttrument.[26–28,30,31] In this study, all participants followed the GT protocol regardless of group allocation, which included a lateral flexion stretch to the contralateral side of treatment.

This confounding factor may have influenced the immediate increase in ipsilateral lateral flexion ROM as the upper trapezius causes ipsilateral lateral flexion.

Limitations

Limitations to this study include the assumption that participant neck pain was a result of trigger points, the variability of blood flow from person to person, and participant demographics. A threat to this study was the perception of participant neck pain being caused by the presence of trigger points in the upper trapezius. The participants in this study were included as a result of self-reported neck pain and the identification of a trigger point by a clinician. However, the clinician had no measurable means of assuring the trigger point(s) identified and treated were the root cause of each participants neck pain. Hemodynamics vary between each participant and it may have been more ideal to capture blood flow changes across the same participants in each group using a cross-over study design. As well, the participants in this study were mostly college-aged; therefore, the limited population causes the results to be difficult to generalize to other populations.

Future research should include an optimal population with more variety in age and employ a multi-faceted evaluation to grasp the nature of a participant's pain. As well, future studies should attempt a cross-over study design to better understand the hemodynamic effects caused by GT on the upper trapezius. Based on current literature, future research examining the effects of GT on blood flow should employ a longer treatment period instead of a single treatment session. After multiple treatment sessions, the relationship between GT and blood flow may be more visible and allow clinicians to gain a better understanding of this treatment technique.

Conclusion

While the direct effects of GT on trigger points in the upper trapezius are still unknown, it is vital for future research to identify the role altered blood flow may play in pain and ROM in neck pain patients. Previous research has established IASTM and GT as treatment techniques for neck pain reduction.[15,29,129–131] However, there is a need for future research to assess GT effects on blood flow, ROM, and pain overtime. The results in the present study found GT, another IASTM instrument, are viable instruments to increase blood flow and increase ROM for people with upper trapezius trigger points. Concurrently, stretching and exercise alone will not cause the same results in a twenty-four-hour period. In conclusion, this study found that after a single treatment, IASTM and the GT protocol have positive benefits on cervical ROM and blood flow to the upper trapezius in patients with neck pain.

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