2016

Manual Therapy Effects on Low Back Pain

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MANUAL THERAPY EFFECTS ON

LOW BACK PAIN

Shelby M. Dale

43 Pages

Context: Instrument assisted soft tissue mobilization (IASTM), specifically the Graston Technique® (GT), uses six stainless steel instruments to mobilize soft tissue by exploiting the principles of transverse friction massage. Muscle energy technique (MET) is an active technique where the patient contracts specific muscles, when instructed, in a specific direction against a distinctly executed counterforce from the clinician. MET is used to mobilize restricted joints, strengthen weak muscles, reduce pain, stretch tight muscles and fascia, increase range of motion (ROM) and improve circulation.

Objective: The purpose of this study was to compare MET in combination with GT to MET in isolation in the treatment of unilateral innominate rotation.

Design: Single-blinded, controlled lab study with randomization

Patients or Other Participants: 30 subjects with self-reported low back pain (LBP). Subjects were randomized into three groups (Control, MET-GT or MET-Only).

Main Outcome Measure(s): LBP was measured using the visual analog scale (VAS), and innominate rotation and hip ROM were measured using the PALpation Meter and digital inclinometer, respectively.

Results: One-way ANOVAs were used to compare changes in visual analog scale (VAS) scores, PALM, and hip flexion and extension ROM measurements over the course of the treatment. Changes in VAS scores between pre-treatment and immediately after treatment showed a significant decrease ($p = 0.046$) for the MET-Only group (11.1 ± 9.4 mm) compared to the control group (0.1 ± 7.5mm).

Conclusions: No other significant differences were found between treatment groups and changes in dependent variables, suggesting that one treatment of combined MET-GT does not significantly decrease LBP, effect innominate rotation or hip flexion and extension ROM immediately after treatment or one week following treatment.

KEYWORDS: Graston®, Instrument Assisted Soft-Tissue Mobilization, Low Back Pain, Manual Therapy, Muscle Energy Technique

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A Thesis Submitted in Partial
Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

School of Kinesiology and Recreation

ILLINOIS STATE UNIVERSITY

2016

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ACKNOWLEDGMENTS

I would like to thank the Illinois State University S.M.A.R.T. clinic and Illinois Wesleyan University Athletics Department for the use of their facilities. I would also like to thank Dr. Noelle Selkow and Dr. Justin Stanek for their contributions in reviewing this manuscript. I would also like to acknowledge Emily Strutner for her assistance with data collection.

S. M. D.

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CHAPTER I

THE PROBLEM AND ITS BACKGROUND

Statement of the Problem

Low back pain (LBP) is a common complaint in the adult population. A study in 2002 found that the percentage of people reporting LBP over a 3-month period corresponded to over 54 million American adults.[1,2] Popular treatment methods for LBP include manual therapy, stretching and core stabilization.[3] Manual therapy is a form of conservative treatment with the aim to reduce pain and increase function through hands-on techniques by a clinician.[4] Manual therapy treatments include soft tissue massage, traction, stretching, joint mobilization, instrument assisted soft tissue mobilization (IASTM) and muscle energy techniques (MET).[5]

One cause of LBP that can be treated with manual therapy occurs from a unilateral innominate rotation. A unilateral innominate rotation can occur when musculature of the abdomen, hip flexors, hip extensors, and back extensors are unbalanced.[6,7] If a patient presents with a unilateral anterior innominate rotation, the ipsilateral hip flexors are often tight and shortened, while the ipsilateral hip extensors are weak and lengthened. In a unilateral posterior innominate rotation, the ipsilateral hip flexors are weak and lengthened, while the ipsilateral hip extensors are tight and shortened.[8] For example, in a unilateral anterior innominate rotation, the ipsilateral rectus femoris and erector spinae are inflexible.[6]

Graston technique® (GT) is a form of IASTM that expands and exploits the principles of transverse friction massage to augment a normal inflammatory response.[9-11] This augmented response is due to the controlled application of microtrauma to the tissue, which promotes healing by increasing the amount of fibroblast recruitment.[10,11] Fibroblasts are responsible for producing fibronectin, which helps to form a blood clot at the injury site and stop the bleeding, as well as protect the underlying tissue from further damage.[10,11] In the stages of the inflammatory response, the fibroblasts take the proteins from the blood clot and replace them with a matrix that more resembles the normal tissue.[10,11] Conditions that can be treated with GT include soft tissue adhesions, restrictions in ROM, myofascial pain, and muscle spasms.[9] GT involves the use of six curvilinear non-invasive stainless steel instruments to break up soft-tissue adhesions, increase circulation to the area and improve ROM. The GT instrument amplifies the feel of the soft tissue under the instruments and allows the clinician to feel a "vibration" or "grittiness" over restrictions in the soft tissue being treated.[9] GT has been shown to increase shoulder ROM in horizontal adduction and internal rotation when applied to the posterior shoulder.[12,13] It has also been used to alleviate pain and decrease soft tissue restrictions associated with carpal tunnel syndrome,[14] DeQuervain's stenosing tenosynovitis,[15] plantar fasciitis,[16] Achilles tendinopathy,[17,18] lumbar compression fracture,[19] lateral epicondylopathy[20] and trigger thumb.[21] However, there has been no published research studying the effects GT may have on the reduction of LBP in relation to unilateral anterior or posterior innominate rotations.

Another form of manual therapy is an active technique called MET where the patient contracts specific muscles, when instructed, in a specific direction against a distinctly executed counterforce from the clinician.[4] MET is claimed to help lengthen shortened muscles, strengthen weak muscles and increase the range of motion (ROM) in hypomobile joints.[22] Previous studies have shown that MET applied to patients with restricted spinal ROM produced acute increases in lumbar extension ROM, active trunk rotation and cervical ROM.[22-24] MET has also been shown to increase passive knee extension immediately following a single application.[22] For unilateral innominate rotation, MET is used to provide a force to correct any asymmetries discovered during an evaluation.[25] Two studies have provided evidence that MET can decrease LBP associated with unilateral innominate rotations,[3,8] but the long-term effects are unknown. It is also unknown how the use of MET and GT in combination will effect hip range of motion (ROM) and unilateral innominate rotation in people with LBP.

Therefore, the purpose of this study was to compare MET in combination with GT to MET in isolation in the treatment of unilateral innominate rotation. We hypothesized that combining MET and GT would produce greater effects on pain and hip ROM than MET in isolation.

CHAPTER II

REVIEW OF RELATED LITERATURE

General Literature Review

Bony Anatomy

The spinal column contains 33 vertebrae, 24 true, movable vertebrae and 9 false or fused vertebrae.[26] The lumbar spine is composed of five vertebrae.[6,26,27] Each vertebra possesses a neural arch for the spinal cord to run through, a spinous process and two transverse processes.[27] The lumbar spine provides significant support for the upper body and transmits body weight and biomechanical stress to the pelvis and lower extremity.[6] Normal curvature of the lumbar spine is lordotic.[26,27] Between each vertebra are intervertebral disks comprised of an annulus fibrosis and nucleus pulposus.[6,26] These disks act as shock absorbers for the spine.[6,26] The primary motions of the lumbar spine are flexion and extension.[27,28] Other motions include rotation, lateral flexion, medial and lateral gliding, anterior and posterior shear, and compression and distraction.[28] The sacrum consists of five fused vertebrae and is positioned inferior to the lumbar spine interlocking with the two innominate bones.[26,27] It has a normal kyphotic curve and is in the shape of a wedge.[27] It forms the key of the arch between the two innominate bones of the pelvis.[6] In the adult body, the sacrum has many depressions and elevations that fit together and increase its stability and strength.[6,26,28] The coccyx is a small bone composed of four fused vertebrae that extends inferiorly and attaches at the apex of the sacrum.[29] The innominate bones or "hip bones" are formed by the fusion of the ilium, ischium and pubis.[29] The ilium consists of the anterior superior iliac spine (ASIS), anterior inferior iliac spine (AIIS), iliac crest, iliac fossa and posterior superior iliac spine (PSIS) and a portion of the acetabulum.[29] The ischium contains the ischial tubercle and another portion of the acetabulum.[29] The pubis is comprised of the pubic tubercle, the final portion of the acetabulum and the pubic symphysis, which is formed when the innominates come together anteriorly.[29] The left and right innominates, along with the sacrum and coccyx, form the pelvis.[27] The pelvis forms a protective bony ring around the inner lower organs and is an important site for muscular attachments.[26] During sitting, standing and activity, the pelvis constantly transmits loads from the lower extremity to the upper extremity and vice versa.[26-28] The pelvis can rotate anteriorly or posteriorly and tilt laterally.[6] Neutral pelvic alignment displays the ASIS slightly lower than the PSIS when compared from the sagittal view.[6] Extending distally from the pelvis is the femur, the longest and strongest bone in the body.[27] Its shape allows for it to accommodate the stresses placed on it during hip and knee range of motion (ROM) and weight bearing.[27] The femur articulates with the tibia, which is the second longest bone in the body and is positioned on the medial side of the lower leg.[27,28] It is the primary weight bearing bone in the leg.[27] The fibula runs parallel to the tibia and its main function is to provide an attachment point for muscles of the lower leg and ankle.[27] The patella is the largest sesamoid bone in the body and is located in the quadriceps muscle and functions in conjunction with the tibiofemoral joint.[27]

Bony Articulations

The articulation between two vertebrae is known as a facet joint and there are ten facet joints in the lumbar spine.[6,27] These facet joints are synovial joints and produce motions such as forward gliding, lateral gliding, compression and distraction.[27,28] The facet joints guide motion and resist shear forces.[28] The most common site for dysfunction in the vertebral column is the lumbosacral articulation at L5-S1, due to the mobility of L5 and the stability of S1.[6] This articulation also bears more weight than the rest of the spine because the center of gravity passes through these vertebrae.[6] Seventy-five percent of lumbar flexion occurs at L5-S1.[27] The angle between L5 and S1 is greater than the other vertebral articulations, which increases the amount of stress on this articulation.[6]

The innominate bones articulate anteriorly at the pubic symphysis and posteriorly with the sacrum.[26] The pubic symphysis is the articulation between the two pubic tubercles and is an amphiarthrodial joint with a fibrocartilage disk in between the tubercles.[6] The pubic symphysis allows for a small degree of spreading, compression and rotation between the two halves of the girdle.[26] The sacroiliac joint (SIJ) is the junction between the sacrum and ilium; it is medial to the PSIS and deep to the thoracolumbar aponeurosis.[29] The SIJ is part synovial joint and part syndesmotic joint.[6,30] The syndesmotic portion of the joint contains intervening fibrous connective tissue that forms into the interosseous sacroiliac ligament.[6,30] The synovial portion of the joint is C-shaped with the convex iliac surface of the "C" facing in the anterior and inferior direction.[6,26] An increase in the angle of the "C" increases the stability of the joint and allows for minimal movement.[6] The articulating surface of the ilium is covered with fibrocartilage while the sacrum's articulating surface is covered with hyaline cartilage that is three fold as thick as the fibrocartilage.[6,26,28,30] The SIJ is the link between the two innominate bones and transfers the weight and forces of the torso to the lower extremity.[26,30] It also provides elasticity to the pelvic ring and buffers impact forces from the lower extremity to the spine.[26] Due to the strong articulation, range of motion at the SIJ is limited; however, the SIJ does produce a small backward, forward motion similar to nodding.[6,26] The SIJ is only able to rotate about four degrees and translate 2mm.[28] If SIJ motion becomes restricted stride length decreases and Trendelenburg's gait occurs due to gluteus medius inhibition.[6] The mobility of the SIJ decreases as a person ages.[28] Stability of the SIJ comes from force closure, form closure and motor control.[6] Force closure and motor control occur when the muscles, neuromuscular units and capsules provide the stability to the joint.[6] Form closure stability occurs due to the joint's shape, coefficient of friction and ligaments.[6] The SIJ is innervated by the dorsal rami of S1-S3.[31] The sacrum and coccyx articulate at the sacrococcygeal joint, which is a fused line with a fibrocartilage disk between the apex of the sacrum and the base of the coccyx.[6] The femur and acetabulum articulate to form the coxafemoral joint, which is classified as a ball and socket joint.[26,29] The articulating surfaces are covered with cartilage and the cartilage of the acetabulum thickens at the periphery joining the acetabular labrum.[26] The distal femur articulates with the tibia to form the tibiofemoral joint.[27] The knee joint is considered a hinge joint, however it can move in flexion, extension, and internal, external rotation. The knee joint also consists of the articulations between the femur and patella, femur and fibula, and the tibia and fibula.[27]

Ligamentous Structures

Ligaments are the main stabilizers during standing and with muscles, provide support to the spine during activity.[28] The lumbar spine is supported by the anterior longitudinal ligament, posterior longitudinal ligament, intertransverse ligament, ligamentum flavum, interspinous ligament, supraspinous ligament and iliolumbar ligament.[6,26-29] The anterior longitudinal ligament extends the full length of the anterior vertebrae and restricts extension.[6,27-29] The posterior longitudinal ligament is within the vertebral canal and extends the full length of the posterior vertebrae, limiting flexion.[6,27,28] The intertransverse ligament connects transverse processes to transverse processes and limits side bending and rotation.[28] The ligamentum flavum is also located within the vertebral column and connects the spinous processes, limiting rotation.[6,28] The interspinous ligament is located between the spinous processes posterior to the ligamentum flavum and limits rotation and flexion.[6,27,28] The supraspinous ligament attaches to each spinous process at the most posterior point of the process and limits flexion.[27,29] The iliolumbar ligament connects the transverse process of L4-L5 to the posterior ilium and stabilizes L4-L5 with the ilium.[6,26,28,29]

The SIJ is stabilized by the anterior sacroiliac ligament, posterior sacroiliac ligament, sacrotuberous ligament, sacrospinous ligament and interosseous sacroiliac ligament.[6,26-29] The strong anterior sacroiliac ligament lines the anterior pelvic cavity and attaches onto the anterior portion of the sacrum.[6,26,27] The dense posterior sacroiliac ligament extends from the apex of the sacrum to around the PSIS.[6,26,27] Both the anterior and posterior sacroiliac ligaments limit all pelvic and sacral movement.[6,26,29] The sacrotuberous ligament attaches to the sacrum and the ischial tuberosity.[27,29] The sacrospinous ligament attaches to the sacrum and ischial spine.[27] The sacrotuberous and sacrospinous ligaments limit nutation and posterior innominate rotation.[27] The interosseous sacroiliac ligament is derived from the syndesmosis mentioned earlier and binds the anterior ilium to the posterior sacrum.[6,26]

The coxafemoral joint is stabilized anteriorly by the iliofemoral ligament, which extends from the ASIS to the intertrochanteric line of the femur and limits hyperextension of the hip.[26] The pubofemoral ligament extends from the pubic ramus to the intertrochanteric line and limits hip abduction and hyperextension.[26] Anteriorly and superficially, the inguinal ligament runs from the ASIS to the pubic symphysis.[26,29] It provides the superior border for the femoral triangle and the lower edge of the abdominal aponeurosis.[26,29] Posteriorly, the ischiofemoral ligament connects the posterior acetabular rim to the inner surface of the greater trochanter of the femur, providing posterior stabilization and limiting extension of the hip.[26] Providing little support but located within the hip joint is the ligamentum teres, which acts as a channel for the arteries that circumflex the hip.[26]

The tibiofemoral joint is stabilized by the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL) and lateral collateral ligament (LCL).[27] The ACL is comprised of three bands that prevent the anterior translation of the tibia during non-weight bearing activities and posterior translation of the femur during weight bearing activities.[27] It also provides stability for tibial internal rotation and a secondary restraint for valgus or varus forces at the knee.[27] The PCL provides resistance for internal rotation of the tibia and prevents hyperextension of the knee.[27] It acts in opposition to the ACL in that it prevents anterior translation of the femur during weight bearing and posterior translation of the tibia during non-weight bearing.[27] The MCL limits valgus forces at the knee and external rotation of the tibia.[27] The LCL works in contrast to the LCL by limiting varus forces at the knee and is taut during knee extension but relaxed during knee flexion.[27] The arcuate ligament is a thickening of the posterior articular capsule and attaches to the fascia of the popliteal muscle and the posterior horn of the lateral meniscus.[27]

Muscles

Trunk flexion involves the lengthening of the erector spinae and the contraction of the rectus abdominis, transverse abdominis, internal and external obliques, rectus femoris, iliopsoas, tensor fascia latae (TFL) and sartorius.[27] The erector spinae is a group of muscles comprised of the spinalis, longissimus, and iliocostalis.[29] These muscles work in concert to extend the trunk and lumbar spine.[29] The erector spinae group shares a common tendon that originates at the posterior surface of the sacrum, iliac crest and spinous processes of the lumbar and thoracic vertebrae.[29] This group of muscles has several insertion points including the posterior ribs, the spinous and transverse processes of thoracic and cervical vertebrae and the mastoid process.[29] The rectus abdominis, transverse abdominis, internal and external obliques provide lumbar stabilization, flexion, side bending and rotation.[28,29] The transverse abdominis, in particular, crosses the SIJ at the proper orientation to provide force closure on the joint when contracted.[28,30] The transverse abdominis originates on the lateral inguinal ligament, iliac crest, thoracolumbar fascia and internal surface of the lower six ribs and inserts on the abdominal aponeurosis allowing it to provide compression of the abdominal contents when contracted.[29] The rectus abdominis originates on the pubic crest and pubic symphysis and inserts on the cartilage of the fifth, sixth and seventh ribs and the xiphoid process.[29] The internal oblique originates on the lateral inguinal ligament, iliac crest and thoracolumbar fascia and inserts on the internal surface of the lower three ribs.[29] The external oblique originates on the external surface of the fifth to twelfth ribs and inserts on the anterior part of the iliac crest.[29] The rectus femoris, iliopsoas, TFL and sartorius provide hip flexion.[29] The rectus femoris originates on the anterior inferior iliac spine and inserts on the tibial tuberosity through the patellar tendon.[29] The iliopsoas is comprised of the iliacus, which originates on the iliac fossa, and the psoas major, which originates on the lumbar vertebrae; both insert on the lesser trochanter of the femur.[29] The TFL originates on the iliac crest and inserts on the iliotibial tract.[29] The sartorius originates on the ASIS and inserts at the pes anserine.[29] Trunk extension involves contracting the erector spinae and gluteals and lengthening the abdominals.[27] The gluteus maximus, medius and minimus provide hip extension and pelvic stability during gait.[29] The gluteus maximus originates on the coccyx, edge of the sacrum, posterior iliac crest, sacrotuberous and sacroiliac ligaments and inserts on the iliotibial tract and the gluteal tuberosity of the femur.[29] The gluteus medius originates on the gluteal surface of the ilium and inserts on the lateral aspect of the greater trochanter.[29] The gluteus minimus originates on the gluteal surface of the ilium and inserts on the anterior aspect of the greater trochanter.[29] Trunk rotation occurs with the contraction of the internal and external obliques.[27] Lateral trunk flexion is initiated by the activation of the quadratus lumborum, internal and external obliques, and latissimus dorsi, iliopsoas and rectus abdominis.[27] The quadratus lumborum originates on the posterior iliac crest and inserts on the last rib and transverse process of the first through fourth lumbar vertebrae and helps with laterally tilting the pelvis.[29] The latissimus dorsi originates on the inferior angle of the scapula, the spinous processes of the last six thoracic vertebrae, the last three or four ribs, the thoracolumbar aponeurosis and the posterior iliac crest.[29] It inserts on the intertubercular groove of the humerus.[29]

Muscles do not provide movement to the SIJ or pubic symphysis but do provide stability.[6] These joints are influenced by the activation of muscles that move the lumbar spine and hips because they attach at the innominates or sacrum.[6] Due to these attachment locations, in order for the pelvis to sit in the proper position the abdominals, hip flexors, hip extensors, and back extensors must all be balanced.[6]

Pelvic Imbalances

In the lower extremity, there are two types of somatic dysfunction, nonphysiologic and physiologic.[28] Somatic dysfunction is defined as an impaired function of components related to the body framework system such as, skeletal, arthrodial and myofascial structures.[24] Nonphysiologic dysfunction produces more pain due to abnormal motions that the pelvis does not typically accommodate and includes shearing of the innominates.[28] Physiologic dysfunction stems more from exertion, and abnormal positioning, including unilateral innominate rotations, flares, nutation or counternutation of the sacrum.[28] Innominate shearing involves an upslip or downslip of the entire hemipelvis. In an upslip the entire hemipelvis moves superior and typically occurs after landing on one leg or falling on the ischial tuberosity.[28] A downslip involves the entire hemipelvis moving inferiorly usually after a forceful pull of the leg.[28,32]

The innominates are able to unilaterally rotate either anteriorly or posteriorly.[6,26-28,30,32-35] Unilateral innominate rotations can interfere with ambulation and cause stress to the SIJ ligaments, anteriorly and posteriorly.[28] An anterior innominate rotation is defined as the entire hemipelvis rotating anteriorly greater then two degrees, so that the ASIS becomes inferior and posterior while the PSIS becomes superior and anterior in relation to the other hemipelvis when compared bilaterally.[8,28,30,33] A posterior innominate rotation is a rotation of the entire hemipelvis in the opposite direction as an anterior innominate rotation.[28,33] If the ipsilateral abdominals and gluteals are lengthened and weak while the ipsilateral iliopsoas and erector spinae are short and strong a unilateral anterior innominate rotation can occur.[6,7,26-28,30] An anterior innominate rotation can also occur from sudden twisting motions such as with a golf swing or hyperextension of the hip or lumbar spine.[28,32] Pain associated with an anterior innominate rotation is often located over the effected PSIS.[28] Unilateral posterior innominate rotation involves inflexibility of the ipsilateral hamstrings, gluteus maximus, rectus abdominis and the obliques.[7,27] Posterior innominate rotation presents with the ASIS superior and anterior and the PSIS inferior and posterior in relation to the other hemipelvis.[28] It can also occur after repeated unilateral stance, falling on the ischial tuberosity or a leg length discrepancy.[26,28] Pelvic asymmetries and leg length discrepancies are interrelated due to the adaption that takes place at the innominates to compensate for the shortened extremity.[28,35]

Flaring of the innominate occurs when the hemipelvis internally or externally rotates in comparison to the other hemipelvis.[28,33] Internal rotation of the hemipelvis is classified as an inflare while external rotation is an outflare.[28,33] Sacral torsion occurs when the sacrum twists between the ilium and occurs as nutation and counternutation.[28] Nutation is anterior rotation or flexion of the sacrum on the ilium while counternutation is the posterior rotation or extension of the sacrum on the ilium.[26,28] Greater muscle action is required to maintain stability of the pelvis with counternutation than nutation and puts the sacrum in a vulnerable position for possible injury.[6] These sacral torsions can occur from lifting and twisting against resistance.[28]

Low Back Pain

According to the 2002 study, back pain was the most frequent type of pain reported accounting for approximately 2.3% of all office visits.[2] Fifty-four million (26.4%) Americans reported low back pain (LBP) within the past 3 months.[2] LBP has been described as "the most common and disabling ailment",[27] "one of the greatest human afflictions",[6] and "a widespread problem that affects both athletic and nonathletic populations".[26] According to Papageorgiou et al.[1] LBP is a symptom with no objective way to measure its presence. In general, LBP does not involve serious or long-lasting pathology but rather has congenital or idiopathic origins.[27,34] Avoiding unnecessary stresses on the spine, correcting biomechanical abnormalities, using proper lifting techniques and maintaining good core stability can all help prevent LBP.[27] Chronic LBP usually results from malalignment of vertebral facets, discogenic disease or nerve root compression.[26,27] Anderson et al.[26] associates LBP with an increase in physical activity and states that the main cause is often musculotendinous strains and ligamentous sprains. Other differential diagnoses for LBP include piriformis syndrome, hip joint pathology, rheumatoid arthritis, myofascial pain, lateral trochanteric bursitis, osteoarthritis, spinal stenosis, spondylolisthesis, ankylosing spondylitis, infection, referred pain or malignancy.[30,36]

Sacroiliac Joint Dysfunction

The presence of nerves in the SIJ allow for the possibility of pain to be perceived and therefore could be a source of LBP.[31] According to Foley,[30] the SIJ is an unappreciated generator of LBP and is thought to be cause at least 15% of LBP. Due to the limited motion at the SIJ and its synovial joint components, the SIJ can have sprains, inflammation and hypermobility or hypomobility.[27] The SIJ refers pain to the groin, low back, gluteals, posterior thigh and the first and second sacral dermatomes.[6,26,28,37] Fortin et al.[31] described an area on the dorsal aspect of the body extending 10cm inferiorly and 3cm laterally from the PSIS that is specific to the SIJ. An SIJ sprain usually occurs after a patient twists both feet, stumbles, falls, steps too hard, runs downhill, punts a ball, lands unilaterally, or bends and twists at the trunk repeatedly.[26,27] The injury may irritate or stretch the sacrotuberous and sacrospinous ligaments decreasing the joint's form closure stability.[26-28] Failure of these ligaments to provide proper stabilization may lead to hypermobility of the joint including anterior or posterior innominate rotation and SIJ dysfunction.[26,27,32] Symptoms of an SIJ sprain include dull, unilateral pain, malaligned ASIS and PSIS, and an increase in pain when lying on the affected side, single leg stance, climbing stairs, prolonged sitting, trunk lateral flexion or straight leg raise beyond 45 degrees, leg length discrepancy, and/or restricted forward bending.[26,37] Treatment of SIJ sprains include cryotherapy, non-steroidal anti-inflammatories, stretching, flexibility, pelvic stability, mobilization and low back strengthening.[26]

When standing, the line of gravity is posterior to the hip so that the body weight is on the posterior aspect of the pelvis.[28] SIJ dysfunction can occur when the line of gravity shifts anteriorly, such as when leaning forward to pick something up, causing the pelvis to rotate anteriorly.[28,34] This rotation occurs due to the inactivation of the abdominal muscles during trunk flexion and increases the stress on the SIJ.[34] The posterior sacroiliac ligaments are put on slack due to the anterior innominate rotation and the anterior sacroiliac ligaments are unable to provide enough support in this position, leaving the SIJ vulnerable to injury and possible dysfunction.[28,34]

Sacroiliac Joint Evaluation

The current gold standard for SIJ dysfunction is an intraarticular fluoroscopically guided injection.[30,38,39] In one study, patients were injected with a contrast medium into the SIJ which caused an increase in pain, while other patients were injected with a local anesthetic and had pain diminished if not completely relieved.[38]

SIJ pathology can be determined using the gapping test, approximation test, femoral shear, Gaenslen's test, FABER, standing flexion, Gillett's test and the supine to long sit test.[6,26,27,30,37,39-43] In the gapping test the patient lies supine, while the examiner applies cross-armed pressure to the ASIS. If the patient experiences unilateral gluteal or posterior leg pain the test is positive.[6] The approximation test has the patient side-lying while the examiner applies a downward force on the iliac crest. If pain is elicited the test is considered positive.[6] The femoral shear test provides an axial load to a flexed, abducted and laterally rotated thigh; pain is considered a positive test.[6] Gaenslen's test can be done either side-lying or supine. In the side-lying position, the patient's upper leg (test leg) is hyperextended by the examiner while the lower leg is flexed and held at the chest.[6] In the supine position, the patient is positioned near the edge of the table. The patient then brings both knees up to the chest and then lowers the test leg over the edge of the table into extension.[6] Pain over the ipsilateral SIJ is a positive test.[6] The FABER position is considered positive if the patient experiences pain in the SIJ region while the hip is flexed, abducted and externally rotated.[6] The standing flexion test was designed to detect abnormal SIJ movement.[28] The examiner palpates the PSIS with one thumb and the sacral spines with the other thumb. The patient then fully flexes the trunk while the examiner notes the movement of the PSIS. Both PSIS should move at the same time and equal distance. A positive test occurs when one PSIS initiates movement first and travels the farthest forward.[28] Gillett's test is done in the standing position. The examiner palpates the PSIS with one thumb and the sacrum (S2) with the other thumb. Then, the patient is instructed to bring the knee to the chest. The ipsilateral innominate should rotate posteriorly and inferiorly, any other movement such as superior or restricted posterior movement is considered a positive test. The test is repeated on the contralateral side.[6] For the supine to long sit test, the patient begins in the supine position while the examiner palpates the inferior pole of the medial malleoli, comparing bilaterally. The patient is then instructed to sit up and the examiner again compares the medial malleoli bilaterally. If there is a difference in malleoli positioning, it is considered a positive test and it is believed that there is a functional leg length difference due to a pelvic dysfunction.[6] If the limb appears shorter in the supine position and then longer in the sitting position, there is a posterior innominate rotation on the affected side. If the limb appears longer in the supine position and then shorter in the sitting position, there is an anterior innominate rotation on the affected side.[6] The affected side is determined from the previous mentioned tests.

Muscle Energy Technique

Muscle energy technique (MET) is an active technique where the patient contracts specific muscles, when instructed, in a specific direction against a distinctly executed counterforce from the clinician.[3,4,44,45] MET is used to mobilize restricted joints, strengthen weak muscles, reduce pain, stretch tight muscles and fascia, increase range of motion (ROM) and improve circulation.[4,45] MET can be classified as isometric or isotonic contractions.[4] An isometric contraction is a muscle contraction that involves no change in length of the muscle, whereas an isotonic contraction is a muscle contraction that does involve a change in the length of the muscle.[27] Higgins[28] describes the contractions as submaximal and held for 6-10 seconds and repeated three to five times, while others describe holding the contraction for 5 seconds and repeating five times.[33] MET is performed within a resisted ROM, to remove the restriction, the limb is moved towards its barrier or restriction.[4,28] At this point MET is performed to reduce the barrier and increase the ROM.[4,28] The limb is then moved to the new barrier and the MET is repeated.[4,28] MET was shown to improve cervical ROM,[24] trunk rotation[46] and lumbar extension ROM.[23] For the study looking at cervical ROM, the patients were placed in a position at the restriction of movement and then instructed to push their head and neck in the desire direction against the clinician's force and hold the isometric contraction for 3-5 seconds.[24] The patient was then instructed to relax and the clinician then engaged a new barrier of motion.[24] The contractions were repeated two to four times.[24] Normal ROM was achieved if the patient had the same ROM bilaterally (lateral cervical flexion or cervical rotation) or measurements that fell within normal ROM for cervical flexion and extension.[24] Results of the treatment group were compared to a "sham group" and showed a significant increase in overall cervical ROM.[24] Lenehan et al.[46] assessed the effect of MET on trunk ROM and found that a single application of thoracic MET significantly increased ROM for trunk rotation. With the clinician standing behind the seated patient, the patient was placed in spinal neutral and then moved to the barrier of restriction in trunk rotation. The clinician then resisted a side bending isometric contraction performed by the patient for five seconds.[46] The contraction was repeated four times.[46] Schenk et al.[23] also studied the effect of MET on ROM except in the lumbar spine. The patient was side lying, on the opposite side of their side bending restriction, while their hips and knees were flexed until movement occurred at L5-S1.[23] The patient was then moved into maximum rotation of L5-S1 and asked to hold an isometric contraction of the hip adductor muscles for five seconds.[23] The patient was then allowed to relax for three seconds as they were moved to the new barrier of motion.[23] The MET was repeated four times and treatment occurred twice a week for four weeks.[23] Overall, the treatment group significantly increased lumbar extension ROM compared to the control group.[23] There are only a few studies that specifically looked at the effect of MET on LBP. Wilson et al.[3] focused on acute LBP and involved the combined treatment of MET and neuromuscular re-education and resistance training exercises. Patients in this study were placed in a side-lying position on the side opposite their trunk flexion and side-bending restriction. The clinician then palpated the L3 spinous process and extended the patient's legs until motion was felt at L3. The clinician then flexed the patient's upper trunk until motion was felt at L3. The lower trunk was then flexed until motion was felt at L3. The clinician then rotated the patient's upper torso until motion occurred at L3. Lastly, the patient's lower body was side bent (legs lifted off the table) until motion was felt at L3. In this position, the patient was instructed to push their legs down into the examiner's hand for five seconds. After relaxing the patient was moved to the next barrier of motion and the process was repeated four times.[3] Patients then completed a series of neuromuscular re-education and resistance exercises such as the drawing-in maneuver, standing extension stabilization, supine obliques, latissimus dorsi pull-down, hip abduction, dumbbell overhead and modified Romanian dead lift.[3] The control group received a sham MET and then completed the same exercises as the treatment group.[3] Comparison of the control and treatment group measurements showed that MET combined with neuromuscular re-education and resistance exercises was superior to neuromuscular re-education and resistance exercises alone in the treatment of acute LBP.[3] Selkow et al. looked at the short-term effects of MET on pain in individuals with non-specific lumbopelvic pain. Patients' innominate rotation was assessed using the PALpation Meter (PALM). Five SIJ pain provocation tests (SI distraction, SI compression, thigh thrust, Gaenslen's and FABER) were performed with the patient indicating the reproduction of symptoms. Patients receiving MET were then instructed to lay supine on the treatment table with their buttocks just off the edge of the table. The leg with the anteriorly rotated innominate was placed on the clinician's shoulder, while the other leg hung over the edge of the table. The patient was then instructed to push their leg into the clinician's shoulder and push up with the opposite leg into the clinician's hand. The contraction was held for five seconds, with five seconds of rest in between and repeated four times. The control group received a sham treatment, which involved the clinician placing their hands on the ASIS for 30 seconds without exerting pressure on the ASIS.[8] Pain was significantly reduced immediately after the intervention and 24 hours later.[8] Other methods of applying MET to correct an anterior innominate rotation involves the patient lying prone with the examiner on the side to be treated. The patient's leg and hip are flexed over the edge of the table and the foot is placed between the clinician's legs. The clinician's hand then stabilizes the sacral area while the other supports the flexed knee and moves it into greater flexion until the barrier of motion is felt. At this point, the patient is instructed to attempt to straighten the leg by isometrically contracting against the examiner. After 10 seconds, the patient is instructed to relax and the flexed leg is moved to its new barrier.[33] A second method involves the patient supine with the clinician on the affected side. The hip and knee are flexed to the barrier of movement. The clinician then places their hand under the pelvis with the patient's ischial tuberosity resting on the clinician's forearm and the clinician's hand palpating the SIJ. The patient is then instructed to extend the hip isometrically for five to seven seconds and then asked to relax. The MET is repeated two or three times.[33] For a posterior innominate rotation, the patient is prone with the clinician opposite the affected side. The clinician then stabilized the SIJ with one hand and supports the anterior aspect on the patient's knee with the other hand. The affected leg is then extended to its barrier of motion and then the patient is asked to isometrically flex the hip for ten seconds. The patient then relaxes and the leg is extended to its new barrier of motion.[33] Higgins[28] describes the same MET for a posterior innominate except the patient is in the side-lying position on the side opposite the posterior innominate rotation. Higgins[28] also describes a combined MET for an anterior innominate rotation of one leg and a posterior innominate rotation of the other leg. The patient is supine with the leg of the anteriorly rotated innominate flexed at the hip with a fully extended knee while the leg of the posteriorly rotated innominate is kept in knee extension on the table. The clinician places one hand under the lower leg of the anteriorly rotated innominate and on top of the thigh of the posteriorly rotated innominate. The patient is then instructed to push into the clinician's hands for 6-10 seconds. The MET is repeated 3-5 times with the legs moved further into extension or flexion after each contraction.[28]

Instrument Assisted Soft Tissue Mobilization

Instrument assisted soft tissue mobilization (IASTM) uses instruments to achieve effects and benefits of soft tissue mobilization.[47] The instruments detect and amplify the sensation of restrictions in the soft tissue and aid in the treatment of soft tissue dysfunctions.[47] IASTM has been shown to be beneficial in the release of fascial restrictions, breaking down collagen cross-linkages, increasing blood flow and regenerative cellular activity.[48] A previous study in rats showed an increase in fibroblast proliferation, which the researchers believed promoted healing in the soft tissue.[11] Other benefits include maintaining the balance between collagen synthesis and degradation, interfiber distance and lubrication, aligning fibroblasts and myofibroblasts in the direction of stress and restoring joint motion.[47] Graston Technique ® (GT) incorporates the use of six stainless steel instruments and expands and exploits the principles of transverse friction massage.[47] They also provide a mechanical advantage to the clinician and decrease treatment time.[47] The physiological effects of GT include the recreation of the normal inflammation response.[47] The components of a treatment session utilizing GT included a soft tissue warm up, GT, stretching, strengthening and then cryotherapy.[47] Indications for using GT include tendinopathies, fascial syndromes, myofascial pain syndrome, ligament pain syndromes, edema reduction, breakdown scar tissue and adhesions, entrapment syndromes, pre-competition warm-up, post-competition recovery and milking edema.[47] Contraindications include cancer, burn scars, kidney dysfunction, pregnancy, medications, rheumatoid arthritis, acute inflammation, varicose veins, osteoporosis, lymphedema, chronic regional pain syndrome, polyneuropathies, unhealed, closed or non-compliant fractures.[47] Maximum treatment time is 10 minutes with 3-5 minutes per muscle group and 2 days off between treatments.[47] An increase in instrument angle results in deeper penetration as well as heavier pressure promoted healing to a greater degree.[10,47] Previous studies have found that GT can reduce anterior chest pain due to a pectoralis minor trigger point,[49] improve carpal tunnel syndrome,[14] increase posterior shoulder range of motion,[12,13] and decrease the amount of fibrotic adhesions and hypertonicity which increased range of motion, decreased pain and increased functionality in a post-operative ACL rupture.[50] GT has also been shown to be beneficial in other soft tissue restrictions and adhesions, tendinitis, musculoskeletal ailments and ROM restrictions.[15-21,51,52]

Summary

In summary, the SIJ's lack of motion may lead to SIJ sprains and SIJ dysfunction, which can present as LBP. SIJ sprains can result in unilateral innominate rotations, which can be corrected by MET. Unilateral innominate rotations can also result from muscular imbalances and may be corrected by a form of IASTM called GT.

CHAPTER III

RESEARCH DESIGN

Research Design Procedures

Study Design

This study was a single-blinded, controlled laboratory study with randomization. The independent variables were group (Control, MET-GT and MET-only) and time (pre-treatment, immediately after treatment and one week after treatment). The dependent variables were the subjects' self-reported pain using a Visual Analog Scale (VAS), innominate rotation using the PALpation Meter (PALM) and hip flexion and extension ROM using a digital inclinometer.

Participants

Thirty college-aged subjects (14 male, 16 female) volunteered to participate in the study. Demographics are available in Table 1. Inclusion criteria included self-reported LBP lasting less than 6 weeks and a unilateral anterior or posterior innominate rotation of 2 or more degrees compared bilaterally, as measured by the PALM. Exclusion criteria included LBP lasting longer than 6 weeks, back surgery, pregnancy or a specific clinical diagnosis for the LBP, such as spondylolysis. Subjects were also excluded if they had a score higher than a 6 on the VAS. Those that reported above a 6 were believed to have pain severe enough to consult a doctor for further treatment.[8] Using a random number generator, subjects that agreed to participate were randomly divided into the control group, the MET-GT group or the MET-Only group. Before participating in the study, all participants read and signed an informed consent approved by the university Institutional Review Board.

Table 1

Patient Demographics

	Age (years)	Height (cm)	Mass (kg)
Control	21.7 ± 2.1	175.5 ± 13.5	76.0 ± 10.3
MET-GT	21.2 ± 3.9	175.5 ± 8.8	72.6 ± 10.6
MET-Only	21.3 ± 1.8	170.9 ± 7.0	74.0 ± 11.2

Instruments

Visual Analog Scale. The Visual Analog Scale (VAS) allowed for each patient's pain to be quantified and thus statistically analyzed. The reliability of the VAS was found to have an intraclass correlation coefficient (ICC) of 0.97.[53] The scale consists of a 100mm horizontal line with no markings so as to not influence the patient's mark.[53] Subjects were blinded to their previous VAS in order to decrease bias. Participants placed a vertical line on the horizontal line, indicating where they felt their pain was most accurately described. The minimum clinically significant difference was determined to be a 10mm change on the VAS.[54]

PALpation Meter. The PALpation Meter (PALM) (Performance Attainment Associates, St. Paul, MN) is a caliper-inclinometer used to measure pelvic malalignments in relation to innominate rotation, among other things. The caliper tips were placed on the most prominent point of the ipsilateral ASIS and PSIS and compared bilaterally to provide a measurement of unilateral innominate rotation in the sagittal plane.[35] A previous study determined the accuracy to be within one degree of the true measurement.[35] ICC for PALM measurements in this study was calculated to be 0.835.

Procedures

All dependent variables were measured by the same examiner (Examiner 1), who was blinded to the patient's treatment group assignment. Subjects completed VAS-1, indicating pain prior to any treatment. Innominate rotation of the pelvis was then measured using the PALM. Subjects were instructed to stand with feet shoulder width apart in the anatomical position while Examiner 1 palpated the ASIS and PSIS bilaterally *(Figure 1)*. There needed to be a bilateral difference of 2 degrees or more. To determine whether the innominate rotation was anterior or posterior, Examiner 1 performed the long-sit test. The patient was supine on the table with knees flexed and feet resting on the table, while Examiner 1 palpated the medial malleoli bilaterally. The patient then performed a bridge to neutralize the pelvis and was then instructed to relax as Examiner 1 moved the patient's knees into full extension. With Examiner 1 still palpating the medial malleoli, the patient was instructed to sit up as the movement of the medial malleoli was observed to determine if one leg moved proximal or distal in relation to the other, indicating an anterior or posterior innominate rotation, respectively. The pathological side was determined by the side of pain described by the patient and by which leg showed greater movement during the long-sit test.

Figure 1. Innominate rotation measured with the PALM

Goniometric measurements of hip flexion and extension were then measured in a randomized order using a digital inclinometer (SPI-Tronic, Garden Grove, CA). Examiner 1 measured hip flexion with the patient lying supine; the digital inclinometer was placed on the lateral mid-femur with midpoint between the greater trochanter and lateral condyle *(Figure 2)*.[55] The patient was then instructed to raise their leg off the table as high as possible while keeping the knee fully extended.[26] Hip extension was measured with the same digital inclinometer position but with the patient lying prone *(Figure 3)*.[55] The patient was then instructed to lift their straight leg off the table without rotating their lower back to gain more ROM.[26] After all measurements were completed Examiner 1 left the examination room.

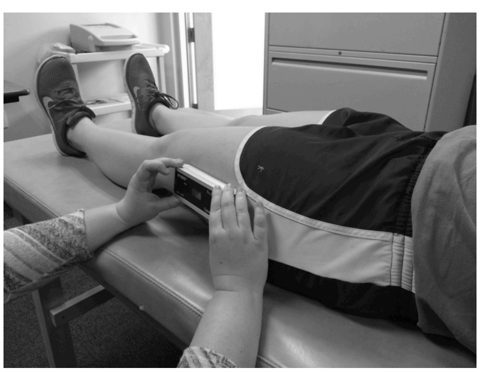

Figure 2. Measuring hip flexion ROM

Figure 3. Measuring hip extension ROM

All participants, regardless of group assignment, completed a 5-minute warm-up on a stationary bike prior to any treatment and a stretching protocol at the end of the session. Examiner 2, who was blinded to dependent variable measurements, instructed the control group to complete the bike warm-up and then lay supine on the treatment table for 5 minutes. After this 5-minute resting period, subjects completed the self-stretching protocol. Subjects in the MET-GT group received MET before GT, while subjects in the MET-Only group were instructed to lay supine on the treatment table for 3 minutes so that total treatment time was equivalent for all groups. Those subjects assigned to receive MET, were instructed to lay supine off the end of the treatment table. Subjects then placed the leg with the anteriorly rotated innominate on Examiner 2's shoulder and the leg with the posteriorly rotated innominate draped off the end of the treatment table with Examiner 2's palm on the patient's quadriceps muscle *(Figure 4)*. Subjects were then instructed to push their leg down into Examiner 2's shoulder, while pushing the contralateral leg up into Examiner 2's hand. This process was repeated for four contractions, held for five seconds with five seconds of rest between contractions.[8]

Figure 4. MET for the hamstring and hip flexor muscles

A certified athletic trainer and clinical practitioner trained in GT (Examiner 2) applied all GT treatments. Emollient was applied over the patient's involved musculature determined by their unilateral innominate rotation. Those subjects with a unilateral anterior innominate rotation received GT over the erector spinae musculature and the rectus femoris muscle. Subjects were prone on the treatment table with legs fully extended for the erector spinae GT treatment. Examiner 2 scanned the erector spinae musculature using the sweep stroke with GT-4 in a multidirectional fashion for 60 seconds. Each restriction was treated for 30-60 seconds in a multidirectional fashion using the fan stroke with GT-4 at a 45° angle to the treatment area. The rectus femoris was treated with the patient supine with legs fully extended on the treatment table *(Figure 5)*. Examiner 2 scanned the rectus femoris using the sweep stroke with GT-1 for 60 seconds. Local restrictions were treated for approximately 30-60 seconds in a multidirectional fashion using the fan stroke and GT-4 at a 45° angle to the treatment area. Subjects with a unilateral posterior innominate rotation received GT over the hamstring muscle group, the rectus abdominis, and the internal and external obliques. The hamstring muscle group was treated with the patient prone with legs fully extended on the treatment table. Examiner 2 used the sweep stroke and GT-1 to scan the hamstring muscle group for 60 seconds. Local restrictions were treated using GT-4 at a 45° angle to the treatment area in a multidirectional fanning stroke for 30-60 seconds *(Figure 6)*. GT was applied to the abdominal muscles while the patient was supine with legs fully extended on the treatment table. The abdominal muscles were scanned using GT-5 in a multidirectional sweep stroke for 60 seconds. Examiner 2 then used GT-4 in a multidirectional fanning stoke at a 45° angle to the treatment area for 30-60 seconds on each local restriction. Total GT treatment time for all involved musculature was 5 minutes.

Figure 5. GT for the rectus femoris using GT-1

Figure 6. GT for the hamstring group using GT-4

Regardless of group assignment, all subjects completed a self-stretching protocol at the end of the session. Subjects with a unilateral anterior innominate rotation were instructed on stretches for the erector spinae and rectus femoris. For stretching of the erector spinae, subjects performed cat camel stretches.[28] Subjects were also educated on basic prone quadriceps stretches with the use of a strap around their foot.[28] They were instructed to flex the knee and attempt to pull the foot to the buttocks with the aid of the strap until tension was first felt.[28] Subjects with a unilateral posterior innominate rotation were educated on stretches for the hamstring and abdominals. Hamstring stretches involved the patient lying supine with a strap around their foot; they were instructed to pull on the strap, lifting the straight leg into hip flexion until tension was first felt.[28] To stretch the abdominal muscles the patient was prone and instructed to prop their upper body up on their elbows, as if watching television.[56] Stretches were held for 30 seconds at the first point of feeling a stretch and repeated three times. Immediately following stretching, Examiner 1 reentered the room and reassessed all subjects' hip ROM and innominate rotation using the PALM. At this time, all subjects also completed VAS-2, indicating pain immediately following the treatment session.

At the end of the session, subjects were instructed to complete activities of daily living as they normally would but were discouraged from doing any type of vigorous or pain provoking activity. Subjects were also instructed to avoid consuming analgesics such as NSAIDs or acetaminophen. All participants returned 7 days after the date of treatment to complete VAS-3, indicating pain one week following treatment, and reassess innominate rotation using the PALM and hip ROM with the digital inclinometer.

CHAPTER IV

ANALYSIS OF THE DATA

Statistical Analyses

There were no significant differences ($p > 0.05$) between groups at baseline. One-way ANOVAs were used to compare change scores of the VAS, PALM and hip flexion and extension ROM measurements over the course of the treatment. An *a priori* alpha level was set at $\alpha \leq 0.05$, and post-hoc t-tests were used to interpret significant findings. Statistical analyses were performed with SPSS Version 20.0 (SPSS Inc., Chicago, IL).

Results and Findings

There was a significant decrease in the VAS change scores between pre-treatment and immediately after treatment: $F(2,27) = 4.05$, $p = 0.029$). Post-hoc testing revealed a significant difference ($p=0.046$, effect size = 0.094 (0.02-1.87)) for the MET-Only group (11.1 ± 9.4 mm) when compared to the control group (0.1 ± 7.5 mm). No significant differences were found between the MET-GT and control or the MET-Only and MET-GT groups ($p>0.05$). No significant differences were found between pre-treatment to immediately after treatment for PALM or hip flexion and extension ROM ($p>0.05$).

A one-way analysis of variance was conducted to compare changes in dependent variables from pre-treatment to one-week following treatment between the three groups. No significant differences were found between pre-treatment to one-week following treatment for changes in VAS scores, PALM or hip flexion and extension ROM ($p>0.05$)

Table 2

Dependent Variable Averages Over Time

	Reliability (ICC)	Treatment	Pre-Treatment	Immediately After	One-Week After
VAS (mm)	0.97[53]	Control	18.2 ± 9.9	18.3 ± 14.4	15.5 ± 8.9
		MET-GT	27.6 ± 11.9	17.0 ± 12.4	15.0 ± 11.7
		MET-Only	26.2 ± 13.0	15.1 ± 10.4	15.3 ± 13.5
PALM	0.84	Control	4.8 ± 2.2	1.7 ± 1.3	3.1 ± 2.1
	(0.66-0.93)	MET-GT	4.9 ± 2.7	1.5 ± 0.9	3.4 ± 2.1
		MET-Only	4.7 ± 2.8	2.0 ± 1.4	2.8 ± 2.0
Hip Flexion	0.87	Control	83.1 ± 10.4	85.6 ± 9.5	87.2 ± 12.6
	(0.72-0.94)	MET-GT	81.9 ± 6.2	88.0 ± 9.0	83.7 ± 12.6
		MET-Only	83.4 ± 12.1	84.4 ± 15.2	89.5 ± 11.3
Hip Extension	0.928	Control	26.1 ± 8.2	27.7 ± 6.1	24.8 ± 7.0
	(0.84-0.97)	MET-GT	24.0 ± 8.0	28.5 ± 8.8	27.7 ± 7.0
		MET-Only	30.3 ± 5.2	32.1 ± 7.5	30.2 ± 7.3

Table 3

Change Scores for Dependent Variables

	Treatment	Pre-treatment to Immediately After	Pre-treatment to One Week After
VAS (mm)	Control	0.1 ± 7.5	2.6 ± 10.1
	MET-GT	10.6 ± 12.2	2.1 ± 15.9
	MET-Only	11.1 ± 9.4	0.2 ± 14.5
PALM	Control	3.1 ± 2.6	1.8 ± 3.0
	MET-GT	3.5 ±2.9	1.6 ± 3.4
	MET-Only	2.7 ± 2.7	1.9 ± 3.3
Hip Flexion	Control	2.5 ± 7.0	4.0 ± 6.2
	MET-GT	6.1 ± 7.0	1.9 ± 8.8
	MET-Only	1.0 ± 6.0	6.1 ± 8.3
Hip Extension	Control	1.6 ±5.5	1.3 ± 4.3
	MET-GT	4.4 ± 4.2	3.6 ±5.0
	MET-Only	1.8 ± 4.0	0.1 ± 6.6

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Conclusions and Implications

The main finding of this study was that the MET group showed a significant decrease in VAS scores from pre-treatment to immediately after treatment when compared to the control group. This result supports previous findings by Selkow et al.[8] that found that the MET group demonstrated a decrease in the worst pain experienced over the past 24 hours as measured by the VAS. The previous study attributed this decrease in pain to the manual contact between the clinician and patient through a decrease in neurophysiological pain. The current study's results also supports the results of the Wilson et al.[3] study, which found that MET decreased pain and showed greater improvement in the Oswestry Disability Index. It is important to point out, however, that in this study, researchers incorporated the use of neuromuscular re-education exercises over 8 treatment sessions, whereas the current study did not. The results of this current study show evidence for the hypothesized effects of MET immediately after treatment on acute LBP.

However, MET did not show a significant difference one week following treatment. It is theorized that the tension placed on the innominates by the facilitated musculature was enough to cause a unilateral rotation of the innominate during activities of daily living (ADLs), explaining the lack of significant findings one week after treatment. It was also theorized that this "tension" in the facilitated muscle groups would be decreased by the use of GT, but this did not occur.

When returning one week after treatment, patients often self-attributed the changes in LBP to changes in their ADLs. For instance, some noted an increase in standing required for work or school. This also points back to the role that facilitated musculature and correlating poor posture has on LBP. Other patients stated they had busier school weeks and were unable to exercise as often as the week prior, which coincides with Anderson et al.[26] theory on how physical activity levels may affect LBP.

Based on the PALM measurements, all groups showed a decrease in innominate rotation. This can be attributed to the stretching protocol that all groups completed. Stretching helps to lengthen the muscle, which in this case may have led to a decrease in muscular tension, and therefore a decrease in innominate rotation. Also, it was assumed for this study that each patient's LBP was caused by the innominate rotation and muscular imbalance however, no special tests were completed to rule out an SIJ sprain or facet dysfunction, which could have been the actual cause of the patient's LBP.

This study also does not offer support for the use of a single session of combined MET-GT to affect acute LBP, innominate rotation or hip flexion and extension ROM. One reason there was no significant findings for the MET-GT group for any dependent variables at any time point could be attributed to the use of only one treatment session. Previous research and case studies utilized multiple treatment sessions (6-10 sessions) to attain results.[14-21,51] Previous research also incorporated a multimodal approach when using GT that incorporated stretching and also strengthening of the treated and affected muscles and fascia.[15-17,48,51,57]

Other factors that could have played a part in the insignificant findings could be the stimulation of nociceptors in the muscle fibers. Many of the subjects in the MET-GT treatment group had never experienced GT or any other manual therapy treatments and could have been hypersensitive to the treatment rendered. As mentioned previously, GT exploits the principles of cross-friction massage to break-up restrictions within the fascia and musculature to separate restrictions in muscles that may restrict movement and stimulate pain. Cross-friction massage with the hands is usually painful, which is exacerbated by the use of the stainless steel instruments involved in GT.[58]

When comparing MET to GT, a clinician must also take into consideration the way in which the tissues are being targeted. While MET is more indirect, it targeted more of the hip flexors and hamstrings than GT because GT only affects those muscles that it is directly applied to. GT was only applied to the rectus femoris; however, the iliopsoas, TFL and sartorius also affect hip extension ROM. For example, Laudner et al. showed that direct targeting of the horizontal abductors and external rotators, which are all easily accessed, increased glenohumeral horizontal adduction and internal rotation.[12] This direct targeting, is beneficial to the muscles that are treated but have no affect on the untreated, synergistic muscles in the surrounding area, which explains why hip ROM was not significantly different between the groups.

As with other studies, there are several limitations to this study, the first being a sample size of only 30 subjects. The sample size was low due to the stringent inclusion criteria for this study. While LBP is a prominent ailment in society, acute LBP (lasting less than 6 weeks) is not as common and any subjects interested in participating noted that they had been experiencing LBP for months or even years. This study also was unable to look at a multimodal approach to treating LBP because we wanted to control or confounding variables in order to see the effects of MET-GT compared to MET and the control group.

In conclusion, the combined use of MET and GT had no effect on LBP measured on the VAS, innominate rotation measured by the PALM or hip flexion and extension ROM, immediately after treatment and one-week following treatment. However, MET alone did show a significant decrease in VAS scores from pre-treatment to immediately after treatment, signifying that MET alone is a viable option to provide immediate relief from LBP. Clinically, there is still no evidence to show how multiple treatment sessions MET-GT will affect LBP, so it may still be a treatment option to consider if a patient is suffering from LBP and other treatment options have failed.

Recommendations for Future Research

Further research should be done to study the effects of multiple treatment sessions on patients with acute LBP to observe a difference in VAS scores, PALM and hip flexion and extension ROM measurements. Continuing research could also incorporate strengthening exercises after GT to utilize a multimodal approach to decreasing LBP. This further research could also look at how strengthening may affect innominate rotation and if strengthening could correct unilateral malalignments between the innominates.

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