2018

The Effect of Muscle Energy Technique on Hip Flexor Tightness

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BARRY UNIVERSITY

COLLEGE OF NURSING AND HEALTH SCIENCES

THE EFFECT OF MUSCLE ENERGY TECHNIQUE ON HIP FLEXOR TIGHTNESS

BY

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A Thesis submitted to the College of Nursing and Health Sciences in partial fulfillment of the requirements for the Degree of Master of Science in Movement Science with a specialization in Injury and Sport Biomechanics – Athletic Training

Miami Shores, Florida

2018

BARRY UNIVERSITY

MIAMI SHORES, FLORIDA

April 24, 2018

To the Dean of the College of Nursing and Health Sciences:

I am submitting herewith a thesis written by Victoria Noel entitled "The Effect of Muscle Energy Technique on Hip Flexor Tightness." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science with a major in Movement Science with a specialization in Injury and Sport Biomechanics – Athletic Training Track.

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Dr. Meredith Parry, Thesis Committee Chair

We, members of the thesis committee,

have examined this thesis

and recommend its acceptance:

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Accepted:

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Chair, Department of Sport and Exercise Sciences

Accepted:

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Dean, College of Nursing and Health Sciences

ACKNOWLEDGEMENTS

First and foremost, thank you to my Lord and Savior Jesus Christ for being a part of my life, and a part of this journey and process. God has given me all I have and everything necessary not only to complete this, but to achieve and be successful in life. If it were not for the Lord, God Almighty, on my side, where would I be? Nowhere. Who would I be? No one. Thank you, Lord, for your grace, love and mercy.

Thank you to my friends and family for supporting me and encouraging me through this process. Much thanks to every subject who participated in the study. Finally, thank you to my thesis committee for working diligently and cooperatively with me to complete this task.

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ABSTRACT

Objective: To examine and compare changes in range of motion (ROM) of hip extension among subjects of different age, gender, and activity frequency, when treated with muscle energy technique for hip flexor tightness. **Methods:** 53 subjects (22 males, 31 females) with hip flexor tightness received one session of muscle energy technique. Subjects performed 5 10-second isometric contractions while in a prone position with 5 seconds of rest between each repetition. Passive hip extension ROM measurements were taken before, immediately after, and 24 hours after application of muscle energy technique. Intersubject variables observed and compared were gender, frequency of physical activity, and age. Intrasubject variability involved the comparison of comparing pre, post, and 24-hour post intervention ROM measurements. **Results:** Gender and activity frequency both did not influence improvements in hip extension. Distribution of age was not large enough; therefore, age was not used as an independent variable. There was a significant difference between baseline ROM measurements when compared to both post and 24-hour post intervention measurements ($p < 0.05$, $p = 0.000$). There were no significant differences between post-intervention and 24 hours after intervention ROM measurements ($p > 0.05$). **Discussion:** Muscle energy technique is an effective form of manual therapy to increase passive hip extension range of motion in individuals with muscle tightness in the hip flexor group. These findings suggest that muscle energy is suitable for use in a rehabilitation regimen or as a form of treatment for muscular tightness for individuals of the general population, regardless of age, gender, and activity frequency.

Level of Evidence: 2c

Keywords: hip flexor tightness, muscle energy technique, range of motion, isometric contraction, intersubject variability, intrasubject variability, manual therapy, hip flexor group

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Table 1

Gender Differences in Mean Passive Hip Extension ROM

Gender	Age (years)	ROM-B	ROM-P	ROM-24P
Female (n = 31)	23.35 ± 5.64	13.68 ± 4.75°*+	17.87 ± 5.04°*	17.55 ± 5.18°+
Male (n = 22)	24.14 ± 3.77	12.46 ± 5.26°*+	16.68 ± 5.23°*	16.68 ± 5.23°+
All (n= 53)	23.75 ± 4.71	13.07 ± 5.01°*+	17.28 ± 5.14°*	17.12 ± 5.21°+

ROM-B = Baseline passive hip extension ROM
ROM-P = Post-MET passive hip extension ROM
ROM-24P = 24-hours Post-MET passive hip extension ROM
*There was a significant difference between ROM-B and ROM-P ($p = .000$, $p < 0.05$).
+There was a significant difference between ROM-B and ROM-24P ($p = .000$, $p < 0.05$).

Table 2

Physical Activity Frequency Differences in Mean Passive Hip Extension ROM

P.A.F.	Age (years)	ROM-B	ROM-P	ROM-24P
Light (n = 20)	22.25 ± 4.51	12.30 ± 4.01°*+	16.40 ± 3.90°*	16.35 ± 3.66°+
Mod. (n = 33)	24.55 ± 5.03	13.70 ± 5.44°*+	17.97 ± 5.69°*	17.69 ± 5.89°+
All (n = 53)	23.40 ± 4.77	13.00 ± 4.73°*+	17.19 ± 4.80°*	17.02 ± 4.78°+

P.A.F. = Physical Activity Frequency
ROM-B = Baseline passive hip extension ROM
ROM-P = Post-MET passive hip extension ROM
ROM-24P = 24-hours Post-MET passive hip extension ROM
*There was a significant difference between ROM-B and ROM-P ($p = .000$, $p < 0.05$).
+There was a significant difference between ROM-B and ROM-24P ($p = .000$, $p < 0.05$).

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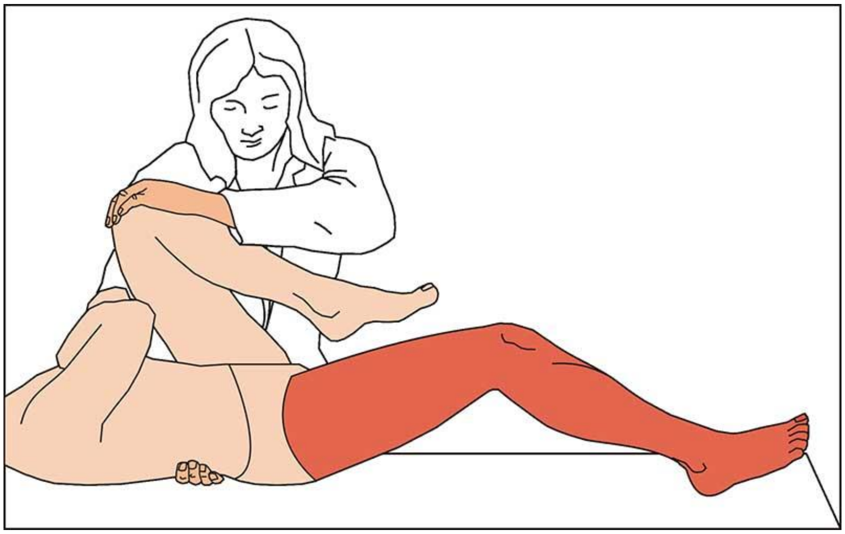

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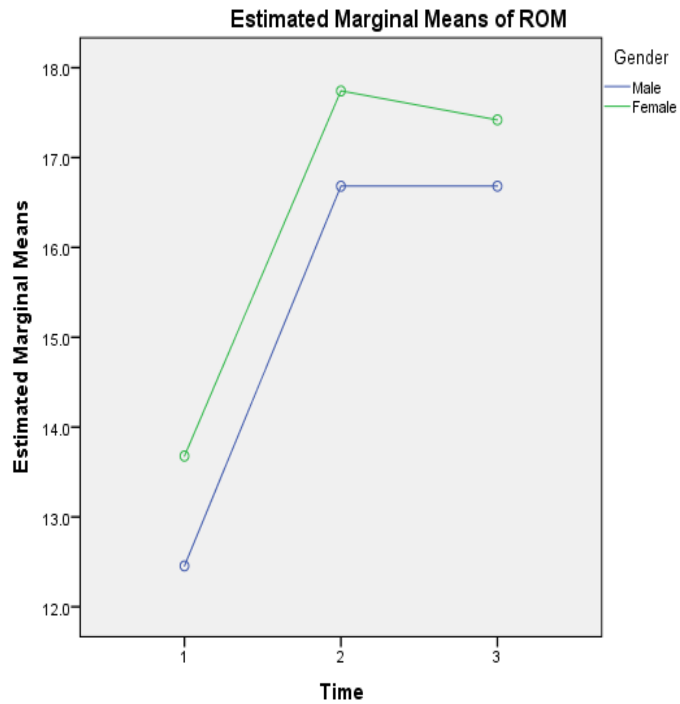

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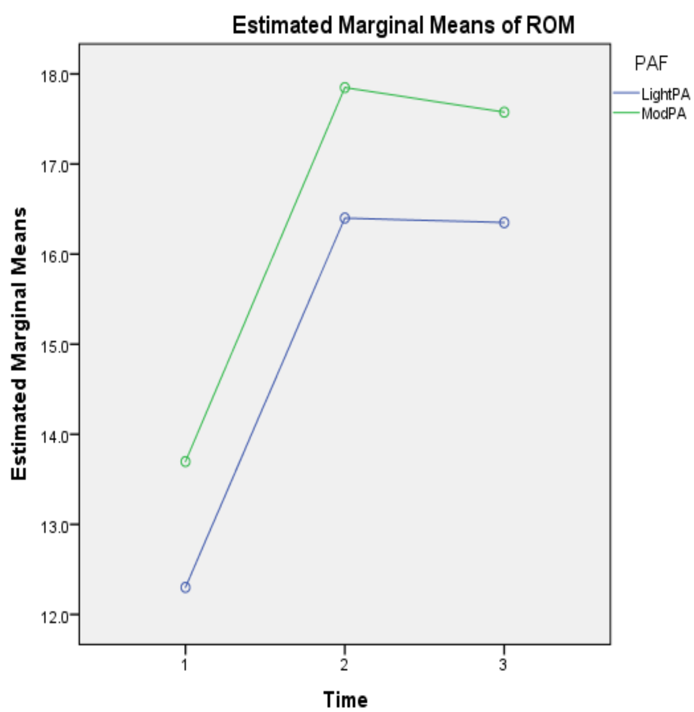

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CHAPTER 1

INTRODUCTION

Hip flexor tightness is a common pathology that many athletes and those of the general population experience (Gillespie & Bubnis, 2018). The term "hip flexors" mainly refers to the three muscles that execute hip flexion: the iliopsoas, rectus femoris, and sartorius. The iliopsoas muscle is the strongest flexor of the hip joint; it consists of the psoas muscle, which originates on the 1st lumbar vertebrae with its insertion on the lesser trochanter of the femur, and iliacus muscle, which runs from the iliac fossa to the lesser trochanter of the femur (Karunaharamoorthy, Becker, & Znotina, 2017). The rectus femoris is one of the muscles of the quadriceps muscle group; thus, its function is mainly knee extension and it assists in hip flexion due to the location of its origin on the anterior iliac spine of the hip (Karunaharamoorthy & Znotina, 2017). The sartorius is also an extensor muscle of the thigh, but because of its location in the anterior compartment of the thigh and its origin on the anterior superior iliac spine, this muscle helps execute hip flexion as well (Karunaharamoorthy & Znotina, 2017). Tight hip flexors can negatively affect core strength and can predispose a person to chronic conditions such as low back pain, hip pain, greater lumbosacral angles and abnormal posture (Gupta, 2016; Garnas, 2014; Maduforo et al., 2012). The combination of the disposition of tight hip flexors along with those secondary and tertiary conditions can also put a person at risk of injury. These can all negatively affect one's quality of life and cause more health issues as they age.

Statement of the Problem

The hip flexor muscles do not become tight typically because of overuse or because of activity. Rather, the hip flexors become tight due to limited to no activity and those muscles remaining passive for extended periods of time. For example, individuals who sit for long periods of time or lead relatively sedentary lifestyles will most likely have tight hip flexors. On average, Americans sit for an average of 13 hours day (Ergotron, 2013). Sitting for long periods of time places the fibers of the muscle(s) in a tightened and shortened state, decreasing the fibers' overall elasticity, or ability to return to normal length. Tight, shortened hip muscles can lead to decreased hip strength, decreased hip range of motion and decrease core strength, which can put an individual at risk of injury (Gupta, 2016). Having this condition also predisposes an individual to have an anterior pelvic tilt, an increased lumbosacral angle, and ultimately an improper posture. Anterior pelvic tilt can lead to lower back pain, knee pain, hypomobility and diminished range of motion (ROM), and other musculoskeletal disorders of the lower extremities (Garnas, 2014). The lumbosacral angle is referred to the angle formed between the long axis of the lumbar vertebrae and the sacrum, and is associated with some degree of instability and low back pain (Maduforo et al., 2012). According to Frank J. D' Ambrosio, a renowned physical therapist of 33 years, states that:

> "Whether we are standing, sitting or lying down gravity exerts a force on our joints, ligaments and muscles. Good posture entails distributing the force of gravity through our body so no one structure is overstressed... like a building with a poor foundation a body with poor posture is less resistant to the strains and stresses we experience over the months, years and decades of life." (D'Ambrosio, 2017)

Thus, having postural deformities can be detrimental to one's quality of life and should be treated as soon as the issue is identified.

Background

There are many available therapeutic modalities and treatment protocols directed towards correcting hip flexor tightness and the associated symptoms. When muscular tightness is present, sport therapists, physicians, and patients themselves, may resort to stretching, massage and thermotherapy since these treatments are indicated for muscle tightness (Holloway, Gotter, & Krucik, 2016). However, when you have tightness within a deep muscle such as the iliopsoas, it may be difficult to achieve a sufficient stretch to bring relief and typical thermotherapeutic modalities are problematic when aiming to heat tissue that is substantially deep. Therefore, a more manual and mechanical method of treatment to more specifically target the hip flexor muscle group may be more effective. Muscle energy technique (MET) is a manual therapy technique available to sport therapists, physiotherapist, and physicians that provides many uses. Some indications for MET are to increase elasticity in muscles (especially postural muscles), strengthen muscles, relax muscles, help regain correct muscle function, and to reduce localized edema (Johnson, 2012).

MET was developed by Fred Mitchell Sr., D.O. originally as an alternative for high velocity manipulations. (D' Ambrogio, 2012). High velocity manipulations are considered potentially more dangerous because it involves a rapid thrust or impulse that can minimize accuracy and can produce a number of side effects such as: local pain or discomfort, headache, tiredness, fatigue, radiating pain or discomfort, paresthesia, and stiffness (Gibbons & Tehan, 2006). For this reason, applying a high velocity manipulation is within the scope of practice of osteopaths and chiropractors, but not within the scope of practice of several other health care practitioners, including athletic trainers and physiotherapists, so it is less available to the patient population. Therefore, Fred Mitchell, Sr., D.O., sought to develop a technique that is safer and more user friendly, MET. MET may be more suitable than other types of therapeutic interventions, like static stretching. While static stretching may address the shortening of a muscle by lengthening it, it may not address or have a significant effect on proprioception, muscular strength, or abnormal posture such as anterior pelvic tilt (Somerset, 2016).

The premise surrounding MET is the Golgi tendon organ. The Golgi tendon organ is a proprioceptor within the tendon of a muscle that senses tension within the muscle, and if the organ senses too much tension, it will inhibit the muscle from exerting any force and relax, protecting from injury (Kravitz, 2016). The basis of this muscle energy technique (MET) is to "reset" the Golgi tendon organ by producing enough force to get the mechanism of the Golgi tendon organ to activate, and ultimately get the muscle to ease and lengthen. When the Golgi tendon organ is reset, the tension and tightness in the tendon and muscle diminishes, allowing the muscle to relax. To complete the reset of the Golgi tendon organ, the patient is placed into a stretch for the muscle being targeted for treatment. The clinician initiates the stretch until the muscle produces the sensation of a barrier and/or restriction. This position must be pain-free for the patient but it is acceptable for it to feel like a slight stretch to the patient. The patient should feel a pull or slight separation within the muscle if done correctly, but if the patient feels pain and discomfort, the therapist has pushed too far and needs to decrease the amount of force applied to the muscle. The patient then performs a voluntary muscle contraction with no more than 25% effort against the resistance of the therapist without moving through a plane, or an isometric contraction (a muscular contraction there is no change in joint angle nor muscle length [Lieber, 2010]), for ten seconds; though there is debate over the degree of force to used (Johnson, 2012). Next, the patient relaxes for three to five seconds, then is placed slightly further into the stretch by the therapist to find a new position provoking a resistive barrier (Johnson, 2012). Research suggests, this treatment routine should be repeated three to five times in one treatment session to produce a result. MET is indicated for patients who experience chronic shoulder, neck, hip, or back pain. Other indications for the use of MET therapy are joint hypomobility, muscle hypertonicity, muscle guarding, and fascial restrictions (D'Ambrogio, 2012). The contraindications for MET are joint instability, fractures, open wounds, sutures, rheumatoid arthritis, and severe, constant pain (D'Ambrogio, 2012). MET is best when incorporated as part of a treatment regimen that includes other therapeutic modalities and therapeutic exercise, and may not be as effective when implemented on its own.

Purpose of Study

There is substantial research regarding the effectiveness of MET for various pathologies affecting the musculoskeletal system, there are no current studies about utilizing this technique for the hip flexor group. Therefore, the purpose of this study is to examine the use of MET as an intervention to treat hip flexor tightness. This study will investigate the duration of the effects of MET on hip flexors tightness and the difference of effects of MET on demographics such as gender and frequency of physical activity. Since hip flexor tightness has a high occurrence in the general population, active individuals will be targeted. Hip flexor tightness will be assessed using the Thomas test and goniometric measurements for hip extension. The goal of this study is to determine if MET is capable of increasing hip ROM and if those increases are only temporary, or if they have a lasting effect on a patient. Intersubject and intrasubject variability of the range of motion (ROM) of hip extension among subjects treated with muscle energy technique for hip flexor tightness will also be assessed. Intersubject variables include gender, frequency of physical activity, and age, and intrasubject variables involves the comparison of pre-intervention measurements, post-intervention measurements, and measurements 24 hours after intervention of each subject.

Operational Definitions

1. Hip flexor tightness: a common condition that involves the shortening of one or more of the flexors of the hip (rectus femoris, iliopsoas, or sartorius) mainly caused by long periods of inactivity or sitting (Somerset, 2016)
2. Range of motion (ROM): the measurement of motion or movement at each joint of the human body (Unbound Medicine Inc., 2017)
3. Muscle energy technique (MET): a manual therapy technique that involves resetting the Golgi tendon organ with three to five short-duration isometric contractions to relive symptoms such as pain, tightness, and decreased ROM (Johnson, 2012)
4. Golgi tendon organ: a proprioceptor within the tendon of a muscle that senses tension within the muscle (Kravitz, 2016)
5. Isometric contraction: a muscular contraction there is no change in joint angle nor muscle length (Lieber, 2010)
6. Indications: symptoms which are deemed valid or suitable to be treated with a specific treatment (Unbound Medicine Inc., 2017)
7. Contraindications: symptoms which are deemed invalid or unsuitable to be treated with a specific treatment (Unbound Medicine Inc., 2017)
8. Thomas test: a manual, medical special test that assesses a patient for hip flexor tightness (Starkey & Brown, 2015)
9. Intersubject variability: changeability between subjects (Dalebout & Robey, 1997)
10. Intrasubject variability: changeability within subjects (Dalebout & Robey, 1997)

Assumptions and Limitations

It will be assumed that subjects will adhere to all instructions and procedures of the study. By agreeing to participate in the study, the researcher assumes the participant adheres and honestly engages in the level of physical activity that is reported at the time of entering the study. Some limitations to the study will be variance amongst subjects' body composition and physical activity experience, since subjects will be obtained from a college setting.

Research Questions

1. What is the immediate effect of muscle energy technique (MET) on hip flexor tightness, pertaining to range of motion (ROM)?
2. How does the effect on ROM differ between individuals treated with MET for hip flexor tightness relating to age, gender, and the frequency of physical activity?
3. How does the effect on ROM differ for hip extension within individuals treated with MET for hip flexor tightness when comparing their own baseline measurements for ROM, post-treatment ROM measurements, and ROM measured 24 after treatment?

Hypotheses

1. A single application of MET will provide a significant, immediate increase in hip extension ROM in subjects with hip flexor tightness, when compared to baseline measurements.
2. Age, gender, and activity frequency will all have an effect and show significant differences in hip extension ROM after MET intervention.

3. There will be a significant difference between hip extension ROM when comparing baseline measurements and immediate post-treatment measurements. However, there will be no significant difference between immediate post-treatment measurements and measurements 24 hours after treatment for hip extension ROM.

Conclusion

Hip flexor tightness is a condition that may affect quality of life and predispose a person to other conditions and chronic health issues. Muscle energy technique is one of many manual therapy interventions that may be useful in addressing all of the detrimental factors of hip flexor tightness, including decreased hip and core strength and decreased hip mobility. Current evidence on the effectiveness of MET on various pathologies will be examined to set parameters for this study and determine if MET is indeed the more effective form of treatment for hip flexor tightness.

CHAPTER 2

LITERATURE REVIEW

Introduction

Hip flexor tightness is a common condition that the average person may have or experience in their lifetime. It is more commonly caused by lack of activity or prolonged sitting (Ergotron, 2013; Gupta, 2016). The tightening and preceding shortening of the hip flexor muscles can lead to changes in posture, such as anterior pelvic tilt, which is assumed to be related to hip and spine pathologies (Gupta, 2016; Garnas, 2014; Maduforo et al., 2012). Available treatments need to be researched to find effective measures to prevent injury and illness. An intervention must be found to possibly reverse symptoms from conditions like hip flexor tightness, such anterior pelvic tilt, to improve quality of life. There is substantial research on techniques, like muscle energy technique, that have been investigated for effectiveness on various health conditions.

Review of Pertinent Literature

Key Themes

The tightening and shortening of the hip flexor muscles may negatively affect hip strength and range of motion, or the measurement of motion or movement at each joint of the body. Hip flexor tightness can pull the hips forward, which can lead to an anterior pelvic tilt due to the tension in the muscles. Upon observation, a person with an anterior pelvic tilt will present with a more extensive lordotic curve, or forward leaning with their abdominals pushed forward and the glutes extending further away from the core (Maduforo et al., 2012). Since hip flexor tightness is associated with anterior pelvic tilt, it can be assumed that anterior pelvic tilt is also a common phenomenon. Herrington (2011) assessed the occurrence of pelvic tilt in a normal, asymptomatic population. Herrington (2011) measured the pelvic angle of 120 healthy subjects, 65 males and 55 females, by placing a PALM palpation meter on the anterior superior and posterior superior iliac spines of the ilium. 85% of the males and 75% of the females presented with an anterior pelvic tilt, 6% of males and 7% of females with posterior pelvic tilt, and 9% of males and 18% of females presented as neutral (Herrington, 2011). This study gives an example of how common anterior pelvic tilt is, and that even though a person may be asymptomatic, they may not even realize they present with this type of abnormal posture.

There should be a concern for someone who presents with hip flexor tightness, and eventually anterior pelvic tilt, even if they are currently asymptomatic. Studies show that posture and hip mobility are greatly affected by pelvic tilt while in motion, and even while standing still. Day, Smidt, and Lehmann (1984) found that anterior tilt increased the depth of the lumbar curve of the vertebral column and influenced the orientation of the head and other parts of the body in both healthy subjects and patients with chronic low back dysfunction. Another study assessed the relation of anterior pelvic tilt during running to peak hip extension range of motion during running and discovered that anterior pelvic tilt tended to be increased in runners who displayed reduced absolute peak hip extension range of motion during terminal stance (Schache, Blanch, & Murphy, 2000). These studies are a few examples that depict the effect anterior pelvic tilt can have on how the body moves and adjusts to certain positions, which can negatively affect quality of life.

When a musculoskeletal issue had been determined, the next mode of operation is to decide how to intervene and treat the problem. Determining the proper treatment protocol involves choosing which modalities to use, the duration of treatment, and estimating the time frame for completing the intervention. In this case, although thermotherapy, massage, and static stretching are indicated for treating muscular tightness (Holloway, Gotter, & Krucik, 2016), hip flexor tightness may require a more manual and mechanical form of treatment since it involves deep musculature. Muscle energy technique (MET) is a form of manual therapy that may be useful in treating hip flexor tightness. MET is used to mobilize joints where movement is restricted, to strengthen weak muscles, to stretch tight muscle and fascia, and to improve local circulation (Goodridge, 1981). This technique involves isometric contractions and calls for varying amounts of force by the patient and counterforce by the operator. The forces applied are dependent on the length and strength of the muscle involved and the patient's symptoms (Goodridge, 1981). Goodridge (1981) also noted that with MET, localization of force is more important than intensity of force and depends on the operator's perception of movement or resistance to movement. Localization depends on the operator's palpatory perception of movement, or resistance to movement, about a specific articulation (Goodridge, 1981). Such perception enables the operator to make subtle assessments about dysfunctions and create variations of suggested treatment procedures (Goodridge, 1981).

There are several forms of manual therapy that are similar to MET, such as proprioceptive neuromuscular facilitation (PNF), that can also be used to help resolve hip flexor tightness. PNF is a stretching technique utilized to improve muscle elasticity and incorporates four theoretical mechanisms: autogenic inhibition, reciprocal inhibition, stress relaxation, and the gate control theory (Hindle et al., 2012). In addition, Hindle et al. (2012) states that each theoretical mechanism is a reflex that occurs when the Golgi tendon organ (GTO) detects harmful stimuli in the tendons of the target muscle, or in the tendons of the antagonist muscle. Autogenic inhibition involves the GTOs from within the contracted or stretched muscle, while reciprocal inhibition involves a voluntary contraction of maximal force in the antagonist muscle of the target muscle, to cause the target muscle to relax (Hindle et al., 2012). Further, the stress relaxation mechanism incorporates utilizing a constant stretch to lengthen the musculotendinous unit; while the gate control theory argues that when a muscle is stretched forcefully past its normal range of motion, the GTOs will be activated in an attempt to reduce injury (Hindle et al. 2012). The efficacy of PNF has supportive research, but there is little evidence of the superiority of each mechanism compared to one another, and compared to other manual therapies and therapeutic modalities.

While both MET and PNF are readily available manual techniques, it is important for a clinician to understand the essential similarities and more importantly the distinct differences in their theory and function. In a direct comparison a clinician can see the many similarities between MET and PNF. Both treatments incorporate the use of isometric contractions at a resistance barrier prior to stretching or movement to serve the objective of normalizing symptoms and detriments caused by various orthopedic conditions (Chaitow & Franke, 2013). Despite these similarities, it is more important to highlight how they differ. Each technique utilizes muscular resistance as a guiding condition to the treatment protocol; however, both use a different classification of what constitutes as muscular resistance. In PNF, the resistance barrier involves moving the muscle or joint to an end range of motion where the patient perceives mild discomfort. With MET, the restriction barrier is classified as the first sign of tension or resistance recognized by the therapist (Chaitow & Franke, 2013). The resistance barrier, which is typically the result of tight muscle or fascia, is not something that you try to overcome with force. Instead, the objective of MET is to pull against the restraints rather than pushing against an anatomical structure (Chaitow & Franke, 2013). PNF also involves a longer and stronger isometric contraction employing all available strength from the patient, whereas MET mainly requests only a maximum of approximately 20% or less of the patient's available force potential (Chaitow & Franke, 2013). MET thrives on its ability to use a gentle effort to cause both local and distant changes along the kinetic chain to aid in the treatment of various mechanical conditions (Chaitow & Franke, 2013). Fred Mitchell, Sr., D.O. uses the following stool analogy to demonstrate the benefits of the gentle effort utilized in MET. In this demonstration, Dr. Fred Mitchell, Sr. applied a quick low amplitude kick to a rolling stool and it moved about 3 - 4 feet; then he put one finger on the stool and pushed it with minimal effort using a longer, yet gentler force, which made the stool travel 6 - 7 feet (Chaitow & Franke, 2013). This demonstration provides an example of the importance of focusing on the intention of how the force is applied in MET rather than focusing on the amount of force applied. MET places the localization of force as more important than the intensity of the force (Goodridge, 1981).

Another major distinction between MET and PNF is in relation to which individual dictates the initiation of the muscular contraction. During PNF, the patient is instructed, by the treating therapist, to "hold" a specific joint position while the therapist applies resistance to build up a maximal isometric contraction in the target muscle group. This theory is contradictory to that of MET; during MET, the patient initiates a non-maximal isometric effort, not the therapist (Chaitow & Franke, 2013). These distinct differences are what gives MET its claims as a technique that is more easily controlled, far less stressful sequence of action for patients and ultimately a safer choice than PNF (Chaitow & Franke, 2013).

The challenge of MET is the accurate application of a non-maximum muscular contraction. There is much debate on the degree of force to be applied during MET; however, it is agreed that the technique calls for firm, yet mild and light contractions (Johnson, 2012). This rather vague description of force application has led to many prescription variations of MET, involving the amount of force of the isometric contraction and the duration of the stretch phase after the isometric contraction. One study by Smith and Fryer (2008) examined the effect of varying MET prescriptive treatments on hamstring flexibility. The study involved 40 asymptomatic participants randomly allocated into one of two groups: MET with a 30-seconds post-isometric stretch phase or MET with a 3-second post-isometric stretch phase. The subjects received their designated intervention twice, with a week in between the applications. The researchers found that both techniques were equally effective in increasing hamstring flexibility, and both groups sustained their improvements in flexibility one week following the initial treatment (Smith & Fryer, 2008). This study suggests that the duration of the passive stretch component of MET does not strongly influence the overall effectiveness of MET, which recommends that there are many ways to manipulate the application of muscle energy technique, yet still yielding significant results. This factor can be useful in creating variability in individual rehabilitation regimens.

Research on MET has also challenged to answer the question of: how long is the optimal duration of the isometric contraction? Fryer & Ruszkowski (2004) attempted to answer this question by examining the effect of various of MET isometric contractions on active atlanto-axial rotation range of motion in subjects who displayed unilateral active atlantoaxial rotation asymmetry of 4 degrees or more. This study compared the application of MET involving a 5-second isometric contraction versus a 20-second isometric contraction. The study found that MET with a 5-second isometric contraction produced the largest increase in rotation in the subjects; thus, a 5-second isometric contraction appears to be optimal in under these conditions. However, it is important to note, moderate effects and improvements in ROM were still achievable with a longer held contraction; they were just not as significant as the short duration isometric hold (Fryer & Ruszkowski, 2004). Results of studies in existing literature, such as these mentioned above, promote the need for further research on determining more prescriptive measures for MET treatment protocols.

Topics of Research

Current literature poses some research on the effect of MET on range of motion in comparison with other therapeutic interventions; with many in support of MET as a preferred method of treatment. One study compared the short-and-long term effectiveness of eight sessions of MET versus a single corticosteroid injection for chronic lateral epicondylitis, and found that even though both MET and corticosteroid injections improved measures of strength, pain, and function when assessed over 6-week, 26-week, and 52-week periods, MET showed better results long term [at 26-weeks and 52-weeks] (Kucuksen et al., 2013). Another study by Burns and Wells (2006) examined the efficacy of muscle energy treatments on the gross range of motion on the cervical spine in asymptomatic individuals. Their study discovered that the application of MET can improve acute range of motion in all three anatomical/cardinal planes for the cervical spine in asymptomatic patients. Patients in the MET group gained approximately 4 degrees of motion in overall regional cervical range of motion when compared with the control group, immediately after receiving treatment.

Phadke et al. (2016) found that MET is a more effective treatment than static stretching for pain, functional disability, and range of motion in patients with mechanical neck pain. Patients for that study were treated for six consecutive days, and even though both groups showed improvements in their baseline scores for the visual analog scale and neck disability index, the MET group had better scores overall. A similar study, looked at the same pathology, using the same interventions of MET and static stretching to treat subacute mechanical neck pain. After 6 sessions of MET for one group, 6 sessions of static stretching for the second group, and a third group with neither treatment, it was determined that thought both the first and second groups were effective at decreasing pain intensity and increasing active cervical range of motion when compared to the control group, however, the MET group showed superior results in comparison to the static stretching group (Mahajan, Kataria, & Bansal, 2012).

Besides the treatment of mechanical pain and the improvement of range of motion, there are studies focused on using MET to treat muscle tightness. Moore et al. (2011) determined that a single application of MET on the horizontal abductors of the shoulder complex can improve general symptoms and improve range of motion in horizontal adduction and internal rotation of the shoulder in baseball players with posterior shoulder tightness. Another study by Suri and Anand (2013) focused on the shoulder complex and investigated the effectiveness of MET in treating shoulder adhesive capsulitis. Their study compared the effectiveness of Maitland mobilization and MET in treating pain and decreased ROM associated with shoulder adhesive capsulitis. Maitland mobilization is a manual therapy technique comprised of passive movements to the joint complex applied at varying speeds and amplitude that may include small-amplitude high velocity therapeutic manipulation, characterized by 5 grades of increasing intensity (Gerstell et al., 2017). After applying either Maitland mobilization or MET in combination with moist hot packs (for 15 minutes) and active ROM to 30 subjects diagnosed with adhesive capsulitis 6 times a week for 2 weeks, researchers found that both treatment groups showed significant improvements in levels of pain and range motion. In this case, Maitland showed better improvements in ROM compared to MET, while MET was superior in reducing pain (Suir & Anand, 2013). The results suggest that both techniques are capable at reducing pain and increasing ROM. The researchers suggest MET could be used to reduce pain primarily, and also use Maitland mobilizations to gain additional ROM later in the rehab regimen (Suir & Anand, 2013).

According to current research, MET seems to also be effective for trigger points. One group of researchers compared the effect of MET and low-level laser on subjects with trapezius and Levator scapula myofascial trigger points. Akbari et al. (2011) examined the effects of standard post-isometric relaxation and stretch prescribed MET versus low-level laser (dosed at 200 ns and 6 J/cm^2) on reducing neck and shoulder pain and disability in patients with myofascial trigger points in the upper trapezius and Levator scapula muscles. The intervention consisted of performing a 10-session treatment program on 30 patients split randomly into even groups. The results indicated that both groups showed significant improvements in reducing pain and disability in the neck and shoulder, without any significant differences between the two interventions (Akbari et al., 2011) Thus, MET is recommended as an excellent form of treatment since it can produce equal or similar results as low-level laser therapy. These results are especially valuable in cases where low-level laser therapy may not be accessible to patients.

Nambi et al. (2013) investigated the differences in effect between ischemic compression and muscle energy technique (MET) on upper trapezius myofascial trigger points, or hyperirritable spots within a taut band of skeletal muscle or in the muscle fascia, that may cause referred pain and motor dysfunction. Ischemic compression is a mechanical treatment of myofascial trigger points that consists of application of sustained pressure for a long enough time to inactivate the trigger points, and on upon of release of the applied pressure, induce reactive hyperemia (Gatterman & McDowell, 2012). Both MET and ischemic compression were paired with ultrasound in treating the myofascial upper trapezius trigger points for 3 sessions a week for 4 weeks with the aim of reducing pain and increasing ROM (Nambi et al., 2013). The researchers found that both groups showed significant decreases in pain scores, but no significant differences when comparing the groups. In addition, the MET group showed greater changes in scores in ROM than the ischemic compression, considering MET as the more effective treatment for trigger points (Nambi et al., 2013). A couple years later, a similar study by Kumar, Sneha, and Sivajyothi (2015) was conducted, comparing the effects of MET, ischemic compression, and strain counter-strain on upper trapezius trigger points. Strain counter-strain, formerly known as positional release technique, is a manual therapy technique that uses passive body positioning of spasmed muscles and dysfunctional joints toward positions of comfort to relax aberrant reflexes that produce the muscle spasm forcing immediate reduction of tone to normal levels (The Jones Institute, 2017). Kumar, Sneha, and Sivajyothi (2015) compared the effect of MET, ischemic compression, and strain counter-strain, all paired with TENS (transcutaneous electric nerve stimulation) on pain, cervical lateral flexion ROM, and neck disability. The intervention included treating 3 groups of 45 evenly distributed subjects 3 times a week for 4 consecutive weeks. The 4-week intervention of ischemic compression, strain counter-strain, and MET all were effective in the treatment of trapezius trigger points, reducing pain and disability and increasing cervical lateral flexion ROM. Again, MET produced the greatest and most significant changes in all three outcomes measures, concluding that MET is the more superior manual therapy technique of the three examined in the study (Kumar, Sneha, & Sivajyothi, 2015).

More importantly, there have been several reputable studies that involve utilizing MET in comparison to another form of manual therapy for the lower extremities. In patients recovering from surgery after joint fractures, joint stiffness and pain may be present. Parmar et al. (2011) evaluated the effectiveness of isolytic MET, which involves using an eccentric contraction where the therapist’s force overcomes the patient’s resistance instead of the standard isometric contraction, compared to passive manual stretching (PMS) in gaining knee ROM and decreasing pain in acute knee involvement in patients who experienced hip fractures. 52 randomly selected patients, divided evenly into the MET and PMS groups were treated for 12 days, and both groups showed significant improvements in pain score and knee ROM; however, the MET showed a significant improvement in pain score, thus deeming the method slightly superior to PMS (Parmar et al., 2011). Lastly, one study found MET more beneficial than the Mulligan Traction Straight Leg Raise technique in increasing knee ROM after providing a treatment protocol 3 times a week on alternate days, for 3 consecutive weeks (Mazumdar & Shriwas, 2014).

Eccentric training, a high intensity form of exercise that involves generated force in contracted, elongated muscles, has been thought to improve muscle extensibility. Therefore, previous studies have investigated the effects of eccentric training against MET on tissue elasticity. A study by Kaur and Reza (2013) found MET produced a more significant increase in hamstring flexibility than eccentric training in sedentary college students that were treated for 14 consecutive days but found no differences amongst males and females. Another study that compared eccentric training to MET was a study done by Sambandham, Alagesan, and Shah (2011), which showed that the immediate effect of MET on hamstring tightness is equivalent to that of eccentric training in healthy females with bilateral hamstring tightness and produces an increase in active knee extension range of motion. These results are significant for clinicians who are prescribing rehabilitation protocols. MET appears to come with many advantages, for one, it is possible that engaging in MET may be simpler for the patient to perform than eccentric training exercises. Since both techniques are effective, one technique can be chosen at the therapist’s discretion without detriment to the success of a rehabilitation program.

Another study that examined hamstring flexibility found MET equivalent to that of static stretching, with both showing an increase in hamstring ROM after five days of treatment along with a home exercise program, compared to using thermotherapy (Ahmed, Miraj, & Katyal, 2010). This is an important find as well, because it shows that MET can be easily incorporated to achieve both strength and flexibility, while providing some variability to a treatment or rehabilitation regimen to prevent the body from adapting to repetitive protocols.

MET has also been used for the lumbar region of the spine and its surrounding musculature. Patil et al. (2010) compared the effect of MET paired with interferential electrical stimulation therapy versus interferential therapy alone on the quadratus lumborum muscle for individuals with acute low back pain. Both treatment protocols helped reduce pain, although MET was shown to have a more significant decrease in disability and increase in spinal range of motion (Patil et. al, 2010). Prior to this study, Naik (2009) examined the effectiveness of MET on acute low back pain, in comparison to positional release technique (PRT). Positional release technique, the original term for strain counter-strain technique, uses tender points and positions of comfort by placing tissues in a relaxed, shortened state and gently pushing the tissue together to relax the muscle spindle mechanism in strained muscle or tissue (Speicher & Draper, 2006). After 8 treatment sessions on 60 subjects (30 in each group) with acute low back pain, Naik (2009) found that both groups showed a significant decrease in pain, increase in amount of lumbar extension ROM, and a decrease in disability level, but there was no statistical significant difference between the effects of one intervention versus the other. A similar study by Hariharasudhan and Balamurugan (2014) tested the effectiveness of MET compared to the strain counter-strain technique (SCS) in reducing pain and disability in subjects with mechanical low back pain. For this study, the researchers evenly split 90 subjects into Group A who received

SCS and Group B who received MET for 5 sessions a week for 8 weeks with both treatments being combined with the use of hot moist packs. The outcome measures of the study were the visual analog scale for pain, the Modified Oswestry Disability Index, and lumbar flexion ROM. The MET treatment group showed significant improvements in all three outcome measures, while the SCS group only exhibited improvements in lumbar flexion ROM. These results suggest MET as the more effective treatment for alleviating pain and disability, and decreasing ROM associated with mechanical low back pain (Hariharasudhan & Balamurugan, 2014).

The effect of MET on the sacroiliac (SI) joint has also been investigated. Sharma and Sen (2014) investigated the effect of MET on pain and disability in subjects with SI joint dysfunction. 20 men and women with unilateral back pain around or near the sacral sulcus and positive muscle tests of resistance to passive movement for the piriformis, erector spinae, and quadratus lumborum muscles were recruited for the study. The subjects were assigned at random either receive MET at 30% force with 10-60 seconds of post-isometric stretch and mobilization, or to be treated with only mobilization of the SI joint for 9 days (Sharma & Sen, 2014). Sharma and Sen (2014) found that the MET group showed a better improvement in pain and disability, but there was no significant difference between the groups in improvements, which ultimately concluded that both techniques are equally effective for the treatment of SI dysfunction. Although both treatments can achieve similar patient outcomes, it is important to recall that performing joint mobilization requires specific training and experience, thus it may be only, or chiefly, performed by highly trained and specialized individuals such as osteopaths and physicians, and is out of the scope of practice for athletic trainers and physiotherapists.

Lastly, there have been a few studies that assess the effectiveness of MET as a modality for the purpose of increasing joint mobility, without the aid of being combined with another therapeutic modality and without being compared to another therapeutic modality. Schenk, MacDiarmid, and Rousselle (1994) studied the influence of MET on lumbar extension range of motion (ROM) in an asymptomatic population and found that after 8 sessions, 2 sessions per week for 4 weeks, lumbar extension ROM was significantly improved. Another group of researchers examined the effect of a single application of MET on the thoracic spine in individuals with restricted active trunk rotation and discovered that MET increased the range of active trunk rotation, but not on the non-restricted side (Lenehan, Fryer, & McLaughlin, 2003). Mehdikhani and Okhovatian (2012) considered the immediate effect of MET on latent myofascial trigger points of the upper trapezius muscle and determined that there was an immediate decrease in pain sensitivity in the upper trapezius muscle, as well as an increase in cervical contralateral flexion. These studies communicate that MET can indeed be effective on its own, without being combined with other interventions, and can be used to treat various musculoskeletal conditions.

Conclusion

Evidence in the literature suggests there is still much debate about the exact degree of force a client should use when contracting a muscle before it is stretched, or elongated. Most evidence advocates low levels of contraction especially for the purpose of MET (Johnson, 2012). A majority of the existing literature on MET involved using the general parameters of: 10 second isometric contractions at about 20 - 30% effort for 3 to 5 repetitions. There was no concrete evidence on how the degree or force of muscle contraction can or should be measured, and what constitutes as a specific percentage of muscular force elicited. In addition, the number of treatment sessions and the length of the treatment protocols varied across current research. Currently, evidence in the literature declares no uniform number of treatment sessions and no specific treatment parameters to produce optimal patient outcomes. These factors pose limitations to implementing MET, and to the development of new studies on MET. Studies exclusively on the application of MET are minimal; while a majority of the studies regarding the effectiveness of MET involve combining it with another treatment, such as exercise programs and thermotherapy, which could influence the results.

Much of the current research has found MET as equally effective as other rehabilitative techniques, which can imply that MET may be beneficial to incorporate more variability in a rehabilitation program and that MET could be another available treatment choice to broaden the scope of practice of many therapists. The current gap in literature seems to be regarding the use of MET on the hip flexor muscle group, therefore guiding the purpose of this research study.

CHAPTER THREE

METHODOLOGY

Introduction

Hip flexor tightness is a common condition in both athletes and the general population. It is mainly brought on by lack of activity, more often than overuse. Tightness of the muscles of the hip flexor group can lead to decreased mobility and range of motion (ROM), decreased muscular strength, and abnormal posture (anterior pelvic tilt); which could lead to more serious conditions involving back and hip pain. Muscle energy technique (MET) is a manual therapy treatment that is indicated for the treatment of hip flexor tightness. Previous studies on MET have had various treatment prescriptions, especially regarding the number of treatment sessions. Therefore, there is no uniform prescription of duration for MET and no set quantity of treatment sessions to provide therapeutic results and improvements. For the sake of this study, each subject will receive one treatment of MET and have their passive ROM of hip extension measured pre-and-post intervention, and 24 hours succeeding treatment.

Organization of the Remainder of the Study

After obtaining a maximum 50 subjects via promotion through the College of Nursing and Health Sciences at Barry University, subjects will receive verbal instruction on what to expect from the study, as well as the opportunity to read and look over a detailed information packet for additional information. Subjects will be obligated to complete the Barry University Consent Form (See Appendix C) and the Health and Demographics Questionnaire (See Appendix B) before participation in any portion of the study. The researcher will be the only individual with access to these forms, and the researcher will be conducting all sessions, including the administration of the muscle energy technique and range of motion measurements with the help of athletic training students from the Athletic Training program at Barry University. All data will be recorded and analyzed by the researcher as well.

Purpose of the Study

The purpose of this study is to determine if a single application of muscle energy technique has an immediate effect on hip extension range of motion in healthy, active individuals with hip flexor tightness and no other symptoms. This study will also explore the difference of the effects of MET between male and female subjects and variations in age and frequency of physical activity.

Research Design of Study

This study involves a deductive approach. A section of the study is descriptive and surveys subjects regarding age, health status, and fitness lifestyle. The remainder of the study is quantitative, involving obtaining degrees of range of motion for hip extension for each subject. To express changes in degrees of range of motion, positive values will indicate an increase range of motion, while negative values indicate a decrease in range of motion.

Sample, Population, and Source of Data

Fifty active individuals (participates in physical activity for at least 30 minutes at least once a week) aged 18 – 50 years old will be recruited for this study. Subjects will be recruited from the student body and faculty of Barry University, via promotion through flyers posted around Barry University’s campus and by word of mouth.

Subjects must complete a health and demographics questionnaire to ensure general well-being and no history nor current implications of severe disease, neuromuscular disorders, and musculoskeletal pathologies. In addition, an informed consent form will be signed prior to being assessed for hip flexor tightness using the Thomas test and participation in any intervention part of the study (See Appendix C). Exclusion criteria of the study includes signs of serious illness (i.e. inflammatory disorders, infections, etc.), history of surgery in the lumbar region of the spine in the past 12 months, history of surgery in the hip and lower extremities in the past 12 months, history of trauma or fractures of the lumbar region of the spine, hip and the lower extremities, neuromuscular issues, and vascular issues.

All subjects included in the study will be evaluated for hip flexor tightness with the Thomas test. Subjects will face exclusion from the study if they are found negative for the Thomas test for hip flexor tightness as well. Participants who meet inclusion criteria will receive a detailed information packet with images to explain the purpose and procedures of the study.

Instruments

A goniometer will be used to measure the passive range of motion (ROM) hip extension for each subject. All subjects will be treated on a standard massage table, and blankets and pillows will be available to subjects for additional comfort if necessary. A health and demographics questionnaire will be administered to survey health status and engagement in physical activity (See Appendix B). The Thomas test will be used as an experimental parameter before and after the intervention. The Thomas test has a moderate inter-rater reliability of 0.58, a sensitivity of 0.41, and a specificity of between 0.33 and 0.83 (Starkey & Brown, 2015). Athletic training students from within the Athletic Training Education Program at Barry University will assist with patient positioning to prevent false positives for the Thomas test. The athletic training students will ensure that the subjects' core is engaged and make sure the lower back of the subject is flat on the table. If the lumbar region of the back is not flat during the Thomas test, it can give a false sense of range of motion and position of the hip joint. The students will also assist with goniometry measurements.

Procedures

Once a participant has been determined to fit the inclusion criteria and a letter of informed consent has been signed and the medical questionnaire has been completed, the assessment and intervention process will begin. Subjects will be instructed to wear light, active clothing and are to expect to be in the laboratory for no more than 20 minutes, and must be available to return to the lab for measurements 24 hours post-intervention, or their first session will be voided and would need to be re-done. To begin, each subject will be evaluated by the Thomas test to check for hip flexor tightness. The Thomas test involves the patient lying supine, and having one leg relaxed, while the opposite leg is placed into knee and hip flexion by the therapist. If the knee of the relaxed side bends and lifts off the table, then the patient is positive for hip flexor tightness. After completing the Thomas test, each subject's passive ROM for hip extension will be measured by a goniometer. The purpose of this measurement is to record a baseline. Passive ROM of hip extension can be assessed with the patient supine and the leg hanging from the table, allowing gravity to pull the leg down allowing for the absence of any active muscular contractions by the patient. Once baseline assessments have been recorded, intervention of MET will begin. This will be initiated by having the subject lay supine with the untreated limb relaxed, and the limb to be treated hanging off the treatment table. The therapist will be standing beside the subject, with one hand stabilizing on the hip and the other hand placed right above the knee, of the side to be treated. The therapist will manually find a resistance barrier or restriction on the side to be treated by moving the subject gently into passive hip extension. The subject will perform a voluntary isometric contraction of the hip flexors by bringing the knee up against the therapist's hand, eliciting a firm yet light contraction. This contraction will be held for ten seconds then immediately followed by five seconds of relaxation; this pattern will be repeated for five repetitions. After each repetition, the therapist will put the patient slightly further into a stretch to find a new resistance barrier, without producing pain. Each subject will receive one application of MET.

Immediately after receiving treatment, hip extension ROM will be assessed again. 24 hours following treatment, hip extension ROM will be determined once more, to compare to results of the baseline measurements and measurements directly post-treatment. Both the goniometry measurements and MET application will be performed only by the researcher, a licensed and certified athletic trainer, to limit variability. The measurements will be assessed and reviewed to determine if there is any variability in changes of ROM before and after intervention. Variations in change of effect will also be explored between subjects of different gender, age and activity frequency.

Statistical Analysis

All data collected for ROM will be assessed and analyzed with Microsoft Excel 2016 and IBM SPSS Version 24.0 (IBM Corporation, Somers, NY, USA). The mean and standard deviations for the values of ROM in degrees will be examined to determine collective increases and decreases in ROM, and to examine intersubject and intrasubject variability. Intersubject variables that will be examined will be gender, frequency of physical activity, and age.

Intrasubject variability is comparing the effects on ROM of the MET treatment immediately after application to the effects on ROM 24 hours after application.

Anticipated Results

All subjects will exhibit significant increases in mean ROM for hip extension after receiving the MET treatment when comparing their baselines to post-treatment. Age, gender, and frequency of activity will have an effect on hip extension ROM and all of these variables will show and produce significant differences amongst the subjects. There will be no difference between measurements for hip extension ROM immediately after treatment and the measurements 24 hours following treatment.

REFERENCES

Ahmed, H., Miraj, M., & Katyal, S. (2010). Effect of muscle energy technique and static stretching on hamstring flexibility in healthy male subjects. *Indian Journal of Physiotherapy and Occupational Therapy, 4*(3), 37-41.

Akbari, A., Naroii, S., Eshgi, M., & Farahani, A. (2012) A Comparison between Muscle Energy Technique with Low-Level Laser in Reducing Neck and Shoulder Pain and Disability in Subjects with Trapezius and Levator Scapula Myofascial Trigger Points. *ZUMSJ, 20*(79), 69-82

Burns, D. K., & Wells, M. R. (2006). Gross Range of Motion in the Cervical Spine: The Effects of Osteopathic Muscle Energy Technique in Asymptomatic Subjects. *The Journal of the American Osteopathic Association, 106*(3), 137-142.

Chaitow, L., & Franke, H. (2013). *Muscle energy techniques* (4th ed.). Edinburgh, UK: Churchill Livingston.

D'Ambrogio, K. (2012, May 11). PT Classroom - Muscle Energy Technique. Retrieved April 12, 2017, from http://www.cyberpt.com/muscleenergytechnique.asp

D'Ambrosio, F. J. (2017, June 07). The Importance of Good Posture. Retrieved November 19, 2017, from https://www.scoi.com/services/physical-therapy/importance-good-posture

Dalebout, S.D. & Robey, R.R. (1997). Comparison of the intersubject and intrasubject variability of exogenous and endogenous auditory evoked potentials. *J Am Acad Audiol., 8*(5), 342 -354.

Day, J. W., Smidt, G. L., & Lehmann, T. (1984). Effect of Pelvic Tilt on Standing Posture. *Physical Therapy, 64*(4), 510-516. doi:10.1093/ptj/64.4.510

Ergotron. (2013, July 17). New Survey: To Sit or Stand? Almost 70% of Full Time American

Workers Hate Sitting, but They do it all Day Every Day. Retrieved November 19, 2017, https://www.prnewswire.com/news-releases/new-survey-to-sit-or-stand-almost-70-of-full-time-american-workers-hate-sitting-but-they-do-it-all-day-every-day-215804771.html

Fryer, G. & Ruszkowski, W. (2004) The influence of contraction duration in muscle energy technique applied to the atlanto-axial joint. *Journal of Osteopathic Medicine 7*(2), 79-84.

Garnas, E. (2017, January 02). 5 Steps for Dealing with Anterior Pelvic Tilt. Retrieved April 21, 2017, from https://www.theptdc.com/2014/06/5-steps-dealing-anterior-pelvic-tilt/

Gatterman, M. I., & McDowell, B. L. (2012). Management of Muscle Injury and Myofascial Pain Syndromes. In *Whiplash* (pp. 85-118). St. Louis, MO: Elsevier Mosby.

Gerstell, F., Tew, D., Lowe, R., Drinkard, D., & Tao, H. (2017, June). Manual Therapy. Retrieved December 21, 2017, from https://www.physio-pedia.com/Manual_Therapy

Gibbons, P., & Tehan, P. (2006). HVLA thrust techniques: What are the risks? *International Journal of Osteopathic Medicine, 9*(1), 4-12. doi:10.1016/j.ijosm.2006.02.005

Gillespie, C., & Bubnis, D. (2018). Tight Hips: 7 Stretches, Symptoms, Causes, Prevention, and More. Retrieved from https://www.healthline.com/health/tight-hips#stretches

Goodridge, J. P. (1981). Muscle energy technique: Definition, explanation, methods of procedure. *American Academy of Osteopathy*, 169-173.

Gupta, D. S. (2016, January 28). How Can I Stay Safe on Ice? Retrieved April 21, 2017, from http://www.everydayhealth.com/news/how-can-stay-safe-on-ice/

Hariharasudhan, R. & Balamurugan, J. (2014). A randomized double-blinded study of effectiveness of strain counter-strain technique and muscle energy technique in reducing pain and disability in subjects with mechanical low back pain. *Saudi J Sports Med,* *14*(2), 83-88

Herrington, L. (2011). Assessment of the degree of pelvic tilt within a normal asymptomatic population. *Manual Therapy, 16*(6), 646-648. doi:10.1016/j.math.2011.04.006

Hindle, K. B., Whitcomb, T. J., Briggs, W. O., & Hong, J. (2012). Proprioceptive Neuromuscular Facilitation (PNF): Its Mechanisms and Effects on Range of Motion and Muscular Function. *Journal of Human Kinetics*, *31*, 105–113. http://doi.org/10.2478/v10078-012-0011-y

Holloway, B., Gotter, A., & Krucik, G. (2016, September 19). Muscle stiffness: Causes, Symptoms and Diagnosis. Retrieved December 18, 2017, from https://www.healthline.com/symptom/muscle-stiffness#modal-close

Johnson, J. (2012). *Therapeutic stretching*. Champaign, IL: Human Kinetics.

Karunaharamoorthy, A., Becker, C. A., & Znotina, L. (2017). Iliopsoas Muscle. Retrieved November 9, 2017, from https://www.kenhub.com/en/library/anatomy/iliopsoas-muscle

Karunaharamoorthy, A., & Znotina, L. (2017). Quadriceps Femoris Muscle. Retrieved November 9, 2017, from https://www.kenhub.com/en/library/anatomy/the-quadriceps-femoris-muscle

Karunaharamoorthy, A., & Znotina, L. (2017). Sartorius Muscle. Retrieved November 9, 2017, from https://www.kenhub.com/en/library/anatomy/the-sartorius-muscle

Kaur, G., & Reza, M. K. (2013). Efficacy of Eccentric Training and Muscle Energy Technique on Hamstring Flexibility in Sedentary College Students. *Indian Journal of Physiotherapy and Occupational Therapy, 7*(3), 93-97.

Kravitz, L. (2016). Muscle Spindle and Golgi Tendon Organ. Retrieved November 19, 2017, from https://www.unm.edu/~lkravitz/Exercise%20Phys/spindleGTO.html

Küçükşen, S., Yilmaz, H., Sallı, A., & Uğurlu, H. (2013). Muscle Energy Technique Versus Corticosteroid Injection for Management of Chronic Lateral Epicondylitis: Randomized Controlled Trial With 1-Year Follow-up. *Archives of Physical Medicine and Rehabilitation*, *94*(11), 2068-2074. doi:10.1016/j.apmr.2013.05.022

Kumar, G.Y., Sneha, P., & Sivajyothi, N. (2015). Effectiveness of Muscle energy technique, Ischemic compression and Strain counterstrain on Upper Trapezius Trigger Points: A comparative study. *International Journal of Physical Education, Sports and Health, 1*(3), 22-26

Lenehan, K.L., Fryer, G. & McLaughlin, P. (2003) The effect of muscle energy technique on gross trunk range of motion. *Journal of Osteopathic Medicine 6*(1), 13-18.

Lieber, R. L. (2010). *Skeletal muscle structure, function, and plasticity: the physiological basis of rehabilitation* (3rd ed.). Philadelphia, PA: Wolters Kluwer.

Maduforo, C., West, O., Nwankwo, N., Onwuchekwa, R., Etawo, U. S., & Ogbulu, D. (2012). Study of the Lumbosacral Angles of Males in Port Harcourt, South- South, Nigeria. *The Nigerian Health Journal, 12*(1), 22-24.

Mahajan, R., Kataria, C., & Bansal, K. (2012). Comparative Effectiveness of Muscle Energy Technique and Static Stretching for Treatment of Subacute Mechanical Neck Pain. *International Journal of Health and Rehabilitation Sciences (IJHRS),1*(1), 16-24. doi:10.5455/ijhrs.00000004

Mazumdar, J., & Shriwas, J. K. (2014). A Comparison Between Mulligan Straight Leg Raise Technique vs. Muscle Energy Technique on Hamstring Tightness in Asymptomatic Male. *International Journal of Physiotherapy and Research*, *2*(2), 412-417.

Mehdikhani, R. & Okhovatian, F. (2012) Immediate effect of muscle energy technique on latent trigger point of upper trapezius muscle. *Clinical Chiropractic, 15*(3-4), 112-120.

Moore, S. D., Laudner, K. G., Mcloda, T. A., & Shaffer, M. A. (2011). The Immediate Effects of Muscle Energy Technique on Posterior Shoulder Tightness: A Randomized Controlled Trial. *Journal of Orthopaedic & Sports Physical Therapy, 41*(6), 400-407. doi:10.2519/jospt.2011.3292

Naik, P.P. (2009). Comparison Of Muscle Energy Technique And Positional Release Therapy In Acute Low Back Pain – RCT. *Orthopaedic & Orthopaedic Manual Therapy*. Dissertation from KLE University, Belagavi, Karnataka

Nambi, G.S., Sharma, R., Inbasekaran, D., Vaghesiya, A., & Bhatt, U. (2013). Difference in effect between ischemic compression and muscle energy technique on upper trapezius myofascial trigger points: Comparative study. *Int J Health Allied Sci., 2*(1), 17-22

Parmar, S., Shyam, A., Sabnis, S., & Sancheti, P. (2011). The effect of isolytic contraction and passive manual stretching on pain and knee range of motion after hip surgery: A prospective, double-blinded, randomized study. *Hong Kong Physiotherapy Journal, 29*(1), 25-30.

Patil, P. N., Chandu, B., Metgud, S., & Khatri, S. (2010). Effectiveness of muscle energy technique on quadratus lumborum in acute low back pain-randomized controlled trial. *Indian Journal of Physiotherapy and Occupational Therapy, 4*(1), 54-58.

Phadke, A., Bedekar, N., Shyam, A., & Sancheti, P. (2016). Effect of muscle energy technique and static stretching on pain and functional disability in patients with mechanical neck pain: A randomized controlled trial. *Hong Kong Physiotherapy Journal*, 35, 5-11. doi:10.1016/j.hkpj.2015.12.002

Sambandham, E. C., Alagesan, J. & Shah, S. (2011). Immediate Effect of Muscle Energy Technique and Eccentric Training on Hamstring Tightness of Healthy Female Volunteers - A Comparative Study. *International journal of current research and review*, 3, 122-26.

Schache, A.G., Blanch, P.D., & Murphy, A.T. (2000). Relation of anterior pelvic tilt during running to clinical and kinematic measures of hip extension. *British Journal of Sports Medicine*, 34, 279-283.

Schenk, R., Adelman, K., & Rousselle, J. (1994). The Effects of Muscle Energy Technique on Cervical Range of Motion. *Journal of Manual & Manipulative Therapy, 2*(4), 149-155. doi:10.1179/jmt.1994.2.4.149

Sharma, D. & Sen, S. (2014). Effects of muscle energy technique on pain and disability in subjects with SI joint dysfunction. *International Journal of Physiotherapy and Research, 2*(1), 305-11

Smith, M., & Fryer, G. (2008). A comparison of two muscle energy techniques for increasing flexibility of the hamstring muscle group. *Journal of Bodywork and Movement Therapies,12*(4), 312-317. doi:10.1016/j.jbmt.2008.06.011

Speicher, T. & Draper, D.O. (2006). Top-10 Positional-Release Therapy Techniques to Break the Chain of Pain: Part 1. *Athletic Therapy Today, 11*(5), 69-71.

Somerset, D. (2016, December 28). Is Stretching the Hips a Bad Idea? Retrieved December 18, 2017, from https://www.theptdc.com/2015/11/why-doing-hip-flexor-stretches-may-not loosen-and-open-up-the-hips/

Starkey, C., & Brown, S. D. (2015). *Examination of Orthopedic & Athletic Injuries* (4th ed.). Philadelphia, PA: F.A. Davis Company.

Suir, S.A. & Anand, M. (2013). Comparative Study on the effectiveness of Maitland

Mobilization Technique Versus Muscle Energy Technique in Treatment of Shoulder Adhesive Capsulitis. *Indian Journal of Physiotherapy and Occupational Therapy, 7*(4), 1-6

The Jones Institute. (2017). About Us - The Jones Institute. Retrieved December 21, 2017, from https://www.jiscs.com/Article.aspx?a=11

Unbound Medicine Inc. (2017) *Taber's Cyclopedic Medical Dictionary* (23rd ed.). F.A. Davis Company.

The Effect of Muscle Energy Technique on Hip Flexor Tightness

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ABSTRACT

Objective: To examine and compare changes in range of motion (ROM) of hip extension among subjects of different age, gender, and activity frequency, when treated with muscle energy technique for hip flexor tightness. **Methods:** 53 subjects (22 males, 31 females) with hip flexor tightness received one session of muscle energy technique. Subjects performed 5 10-second isometric contractions while in a prone position with 5 seconds of rest between each repetition. Passive hip extension ROM measurements were taken before, immediately after, and 24 hours after application of muscle energy technique. Intersubject variables observed and compared were gender, frequency of physical activity, and age. Intrasubject variability involved the comparison of comparing pre, post, and 24-hour post intervention ROM measurements. **Results:** Gender and activity frequency both did not influence improvements in hip extension. Distribution of age was not large enough; therefore, age was not used as an independent variable. There was a significant difference between baseline ROM measurements when compared to both post and 24-hour post intervention measurements ($p < 0.05$, $p = 0.000$). There were no significant differences between post-intervention and 24 hours after intervention ROM measurements ($p > 0.05$). **Discussion:** Muscle energy technique is an effective form of manual therapy to increase passive hip extension range of motion in individuals with muscle tightness in the hip flexor group. These findings suggest that muscle energy is suitable for use in a rehabilitation regimen or as a form of treatment for muscular tightness for individuals of the general population, regardless of age, gender, and activity frequency.

Level of Evidence: 2c

Keywords: hip flexor tightness, muscle energy technique, range of motion, isometric contraction, intersubject variability, intrasubject variability, manual therapy, hip flexor group

Introduction

Background

Hip flexor tightness is a pathology that athletes and those of the general population may experience.[1] The term "hip flexors" mainly refers to the three muscles that execute hip flexion: the iliopsoas, rectus femoris, and sartorius. [2-4] The hip flexor muscles do not become tight typically because of overuse or activity. Rather, the hip flexors become tight due to limited to no activity and those muscles remaining passive for extended periods of time. For example, individuals who sit for long periods of time or lead relatively sedentary lifestyles will most likely have tight hip flexors. On average, Americans sit for 13 hours day.[5] Sitting for long periods of time places the fibers of the muscle(s) in a tightened and shortened state, decreasing the fibers' overall elasticity, or ability to return to normal length. Tight, shortened hip muscles can lead to decreased hip strength, decreased hip range of motion and decrease core strength, which can put an individual at risk of injury.[6] Having this condition also predisposes an individual to have an anterior pelvic tilt, an increased lumbosacral angle, and ultimately an improper posture. [6-8] Anterior pelvic tilt can lead to lower back pain, knee pain, hypomobility and diminished hip range of motion (ROM), and other musculoskeletal disorders of the lower extremities.[7] The lumbosacral angle is referred to the angle formed between the long axis of the lumbar vertebrae and the sacrum, and is associated with some degree of instability and low back pain.[8] These can all negatively affect one's quality of life and cause more health issues as they age.

There are many available therapeutic modalities and treatment protocols directed towards correcting hip flexor tightness and the associated symptoms. When muscular tightness is present, sport therapists, physicians, and patients themselves, may resort to stretching, massage and thermotherapy since these treatments are indicated for muscle tightness.[9] However, when you have tightness within a deep muscle such as the iliopsoas, it may be difficult to achieve a sufficient stretch to bring relief, and typical thermotherapeutic modalities are problematic when aiming to heat tissue that is substantially deep. Therefore, a more manual and mechanical method of treatment to more specifically target the hip flexor muscle group may be more effective. Muscle energy technique (MET) is a manual therapy technique that provides many uses and is available to sport therapists, physiotherapists, and physicians. Some indications for MET are to increase elasticity in muscles (especially postural muscles), strengthen muscles, relax muscles, help regain correct muscle function, and to reduce localized edema.[10]

MET was developed by Fred Mitchell Sr., D.O. originally as an alternative for high velocity manipulations.[11] The basis of this muscle energy technique (MET) is to “reset” the Golgi tendon organ (GTO) by producing enough force to get the mechanism of the GTO to activate, and ultimately get the muscle to ease and lengthen. To complete the reset of the GTO, the patient is placed into a stretch for the muscle being targeted for treatment. The clinician initiates the stretch until the muscle produces the sensation of a barrier and/or restriction. This position must be pain-free for the patient, but it is acceptable for it to feel like a slight stretch to the patient. The patient should feel a pull or slight separation within the muscle if done correctly, but if the patient feels pain and discomfort, the therapist has pushed too far and needs to decrease the amount of force applied to the muscle. The patient then performs a voluntary isometric contraction (a muscular contraction there is no change in joint angle nor muscle length) [12] with no more than 25% effort against the resistance of the therapist for ten seconds; though there is debate over the degree of force to used.[10] Next, the patient relaxes for three to five seconds, then is placed slightly further into the stretch by the therapist to find a new position provoking a resistive barrier. [10] Research suggests, this treatment routine should be repeated three to five times in one treatment session to produce a result. [10]

MET is indicated for patients who experience chronic shoulder, neck, hip, or back pain. Other indications for the use of MET therapy are joint hypomobility, muscle hypertonicity, muscle guarding, and fascial restrictions.[11] The contraindications for MET are joint instability, fractures, open wounds, sutures, rheumatoid arthritis, and severe, constant pain.[11] MET may be more suitable than other types of therapeutic interventions, like static stretching. While static stretching may address the shortening of a muscle by lengthening it, it may not address or have a significant effect on proprioception, muscular strength, or abnormal posture such as anterior pelvic tilt.[13] MET is best when incorporated as part of a treatment regimen that includes other therapeutic modalities and therapeutic exercise and may not be as effective when implemented on its own.

Objectives

There is substantial research regarding the effectiveness of MET for various pathologies affecting the musculoskeletal system. However, there are no current studies about utilizing this technique for the hip flexor group. Therefore, the purpose of this study was to examine the use of MET as an intervention to treat hip flexor tightness. This study investigated the duration of the effects of MET on hip flexors tightness and the difference of effects of MET on demographics such as age, gender, and frequency of physical activity. Since hip flexor tightness has a high occurrence in the general population, active individuals from the general population were targeted. Hip flexor tightness was assessed using the Thomas test and goniometric measurements for hip extension were examined. The goal of this study was to determine if MET increases hip extension ROM and if those increases are only temporary, or if they have a lasting effect on a patient hip extension ROM. Intersubject and intrasubject variability of the range of motion (ROM) of hip extension among subjects treated with muscle energy technique for hip flexor tightness was also assessed. Intersubject variables included gender, frequency of physical activity, and age, and intrasubject variables involves the comparison of pre-intervention measurements, post-intervention measurements, and measurements 24 hours after intervention of each subject. It was hypothesized that age, gender, and activity frequency would influence and show significant differences in overall hip extension, but all subjects would not have significant differences between post-intervention and 24 hours after intervention ROM measurements.

Methods

Study Design

This study involves a deductive approach. A section of the study was descriptive and surveyed subjects regarding age, health status, and fitness lifestyle. The remainder of the study was quantitative, involving obtaining degrees of range of motion for hip extension for each subject using goniometry. Participants attended two sessions: the first included administering the Thomas test, a pre-intervention range of motion (ROM) measurement, a single application of muscle energy technique, and a post-intervention ROM measurement; the second session only involved one ROM measurement 24 hours after the subject received treatment. All recruited participants were screened for eligibility to receive intervention; there was no control group, all participants underwent intervention and neither the therapist nor subjects were blinded to who received the treatment. To enhance reliability, only one certified therapist conducted all interventions; this therapist was the primary researcher. Results were withheld from participants until the completion of both sessions to minimize bias, and all results were kept confidential across all participants.

Setting

Individuals recruited for this study were males and females ranging from ages 18 – 50 years old who participate in physical activity for at least 30 minutes at least once a week. Physical activity was classified as either running, walking, weight training, yoga, aerobics, or sports. Subjects were recruited from the student body, faculty, and staff of Barry University, via promotional flyers and word of mouth throughout all of Barry University's campus. Flyers were posted on campus for 3 weeks. Flyers included a brief description of the study and contact information of the primary investigator so that individuals can contact her by email or phone. Data collection was conducted in a private laboratory on campus to maintain the privacy and confidentiality of the participant. Participation was entirely voluntary, and participants could withdraw from the study at any time without consequence. Data was collected at a specific time for each subject, and there was no follow-up intervention or treatment.

Participants

Fifty-six subjects were recruited from the student body, faculty and staff of Barry University. Each subject who volunteered for the study signed an informed consent form and completed a health and demographics questionnaire to ensure that the participant met the inclusion criteria. Inclusion criteria included males and females, ages 18 – 50 years old, who participate in physical activity for at least 30 minutes at least once a week and have no history of, nor current implications of, severe disease, neuromuscular disorders, and musculoskeletal pathologies. The final criteria for inclusion was the presentation of hip flexor tightness; subjects were evaluated for hip flexor tightness with the Thomas test. Exclusion criteria of the study included lack of hip flexor tightness, signs of serious illness (i.e. inflammatory disorders, infections, etc.), history of surgery in the lumbar region of the spine, hip or lower extremities in the past 12 months, history of trauma or fractures of the lumbar region of the spine and/or the lower extremities, neuromuscular disorders, and vascular disorders. This study was approved by Institutional Review Board at Barry University.

Variables

The independent variables examined for this study were gender, male or female, and frequency of physical activity, light or moderate. The dependent variables were baseline ROM measurements, post-intervention ROM measurements, and 24-hours post-intervention ROM measurements. Age was originally selected as an independent variable; however, age showed a very weak positive correlation with ROM, thus it was only displayed as a dependent variable.

Data Sources/Measurement

Fifty-six individuals were recruited for this study from the student body, faculty and staff of Barry University. After completion of the consent form and the health and demographics questionnaire to determine the presence of inclusion criteria, each subject was assessed for hip flexor tightness with the Thomas test. The Thomas test involves the patient lying supine, and having one leg relaxed, while the opposite leg is placed into knee and hip flexion by the therapist (See Figure 1). If the knee of the relaxed side bends and lifts off the table, then the patient is positive for hip flexor tightness. After the presence of hip flexor tightness was determined via a positive Thomas test, an exact measurement of passive ROM for hip extension was measured with a 12-inch goniometer. The purpose of this initial measurement was to obtain a baseline measurement for ROM of the hip flexors. Passive ROM of hip extension can be assessed with the patient supine and the leg hanging from the table, allowing gravity to pull the leg down allowing for the absence of any active muscular contractions by the patient. Immediately after baseline assessments were recorded, each subject received a single application of muscle energy technique (MET).

MET for the hip flexor group is executed by having the subject lay supine with the untreated limb relaxed, and the limb to be treated hanging off the treatment table, the same position where passive ROM was measured. The therapist stands beside the subject, with one hand stabilizing on the hip and the other hand placed right above the knee, of the side to be treated. The therapist manually finds a resistance barrier or restriction on the side to be treated by moving the subject gently into passive hip extension. The subject performs a voluntary isometric contraction of the hip flexors by bringing the knee up against the therapist's hand, eliciting a firm yet light contraction (See Figure 2). This contraction is held for ten seconds then immediately followed by five seconds of relaxation; this pattern will be repeated for five repetitions. After each repetition, the therapist puts the patient slightly further into a stretch to find a new resistance barrier, without producing pain. Each subject will receive one application of MET bilaterally.

Immediately after receiving the MET intervention, a new measurement for hip extension ROM was recorded. Twenty-four hours following the initial intervention, the participant met with the primary researcher to obtain one final measurement of hip extension ROM. This 24-hour post intervention measurement was used for a comparison to the results of the baseline measurements and the immediate post-intervention measurements. To limit variability, both the goniometric measurements and MET application were performed solely by the primary researcher, a licensed and certified athletic trainer. The data was analyzed to determine if there were any significant changes in hip flexor ROM before and after intervention. Variations in change of effect was also explored between subjects of different gender, age and activity frequency.

Bias

Careful measures were taken to help avoid any possible bias in this study. The primary researcher is a licensed/certified athletic trainer; thus, limiting the chance of error and adverse effects. In addition, all subjects had coded IDs and each subjects' range of motion measurements were recorded in different locations, deeming it difficult to refer to previous sessions for specific participants, which can minimize bias.

Study Size

A statistical priori power analysis using G*Power 3.1[14] was ran to determine the optimal sample size needed to optimize the significance of the results of this study. For a power of .95 and an alpha level of 0.05 used to determine significance level, a minimum of 50 participants was recommended to achieve a large effect size (0.95).

Quantitative Variables

The subjects' ages were kept as their true numerical values, measured in years. The subjects' gender was denoted with a binary code; "0" for male and "1" for female. Frequency of activity was also given a binary code: "0" represented engaging in light physical activity, which was defined as exercising 1 to 3 days a week, while "1" represented engaging in moderate physical activity, which was defined as exercising 4 or more days a week. The range of motion values were kept as their true numerical values as well, measured in degrees. Statistical analysis was completed with IBM SPSS Version 24.0 (IBM Corporation, Somers, NY, USA).

Statistical Methods

All data collected for ROM was assessed with Microsoft Excel 2016 and analyzed with IBM SPSS Version 24.0 (IBM Corporation, Somers, NY, USA). The values of ROM, in degrees, were compared between gender, frequency of physical activity, and age to determine average change in ROM. Average changes in ROM that occurred immediately after the MET treatment application, and 24 hours after application were compared to baseline measurements taken before the MET application. Two separate one-way repeated measures ANOVA tests were performed to determine the effect of MET on passive hip extension ROM, in degrees. When a significant main effect was found, a follow-up paired samples t-test was conducted. An alpha level of 0.05 was used to determine significance level.

Results

Participants

Fifty-six subjects were recruited for this study. Two subjects were excluded from the study due to meeting exclusion criteria. One case was eliminated due to extreme values which may have occurred because of human error. Therefore, fifty-three subjects, 22 males and 31 females, (23.75 ± 4.71 years) fully participated in this study. Two separate one-way repeated measures ANOVA tests were performed to determine the effect of MET on passive hip extension ROM, in degrees. The values for ROM, in degrees, were examined and compared between gender, frequency of physical activity, and age to determine average change in ROM. Males had an average of approximately 12° (± 5.26) passive hip extension at baseline, 17° (± 5.23°) post-intervention, and 17° (± 5.23°) 24-hours post-intervention; while women averaged 14° (± 4.75°), 18° (± 5.04°) post-intervention, and 18° (± 5.18°) 24-hours post-intervention of passive hip extension, respectively (See Table 1). Those who engaged in light physical activity had an average of 12° (± 4.01°) passive hip extension at baseline, 16° (± 3.90°) post-intervention, and 16° (± 3.66°) 24-hours post-intervention; while those who engaged in moderate physical activity averaged 14° (± 5.44°), 18° (± 5.69°) post-intervention, and 18° (± 5.89°) 24-hours post-intervention of passive hip extension, respectively (See Table 2). Average changes in ROM that occurred immediately after the MET treatment application, and 24 hours after application were compared to baseline measurements taken before MET application. The average increase in ROM for males and females was approximately 5° and 4°, respectively. The average increase in ROM for those who engage in light and moderate activity were both 4°.

Main Results

There was no significant difference in passive hip ROM between subjects of different gender ([See Table 1], $p = .464$, $p > 0.05$), and no significant interaction between gender and each of the three ROM measurements (See Figure 3). In addition, there was also no significant difference between ROM between those who engaged in light physical activity compared to moderate physical activity ([See Table 2], $p = .330$, $p > 0.05$); nor was there a significant interaction between frequency of physical activity and each of the three ROM measurements (See Figure 4). There was not a large enough distribution of ages to separate them into groups to create clinical meaning. Therefore, age was not used as an independent variable. Nevertheless, age showed a weak positive correlation to ROM ($r = 0.294$, $r^2 = 0.086$). There was a significant difference between baseline measurements compared to post-MET application measurements ($p = .000$), and a significant difference between baseline measurements compared to 24-hours post-MET measurements ($p = .000$). However, there was no significant difference between post-MET application measurements and 24-hours post-MET measurements ($p = .510$, $p > 0.05$).

Discussion

Key Results

This is the first study of the primary researcher's knowledge that investigated the effect of muscle energy technique (MET) on hip flexor tightness. There were no reported adverse effects associated with receiving a single application of MET. None of the subjects experienced pain or any other symptoms during the study. Some participants noted that they felt their hip extension improving after a few repetitions of MET. Since there was no significant difference between post-MET application ROM and ROM 24 hours post-MET application, this means that the improvements in hip extension ROM from 1 intervention of MET were maintained over a 24-hour period. The increase in passive hip range of motion post-MET application compared to baseline, and that sustained increase in ROM after 24 hours, supports that MET can be an effective treatment for muscular tightness and may produce noticeable improvements. This study suggests that MET could be incorporated in a treatment or rehabilitation regimen on alternating or non-consecutive days because of its immediate and retained effect on ROM. In addition, the findings of this study show that regardless of gender and frequency of physical activity, MET is a safe and effective way to improve ROM in relatively active individuals of the general population.

Limitations

The subjects of the study were only given a single application of muscle energy technique, which might have limited the ability to find significant results. In addition, the subjects were not monitored during the 24-hour window between the second range of motion measurement and the third range of motion measurement. Even though subjects were advised to not engage in strenuous physical activity during their participation in the study, ultimately, the researcher had no control over the activities the subjects may have engaged in during their participation in the study and in between sessions. Some other limitations to the study could be variance amongst subjects' body composition and physical activity experience.

Interpretation

Even while considering the limitations of the study, the findings of this study indicate that MET may be an effective manual therapy technique for muscular tightness. One application of MET produced an increase in ROM and subjects were able to sustain their improvements in ROM over a 24-hour period. Previous research found that subjects with hamstring tightness that received one application of one of two variations of MET twice, with a week between each treatment session, showed an increase in hamstring flexibility and were able to retain their ROM improvements for one week after each treatment.[15] One group of researchers discovered that a single application of MET on the thoracic spine in individuals with restricted active trunk rotation increased the range of active trunk rotation, but not on the non-restricted side.[16] Another group of researchers examined the effect of a single application of MET on the horizontal abductors of the shoulder complex, discovering that MET can improve general symptoms and improve range of motion in horizontal adduction and internal rotation of the shoulder in baseball players with posterior shoulder tightness.[17] The results of our study support previous research in that a single application of MET can be quite useful and effective in improving ROM in restrictive areas of the body.

Previous research has also examined the effect of MET compared to another modality or treatment. For example, one study compared the short-and-long term effectiveness of eight sessions of MET versus a single corticosteroid injection for chronic lateral epicondylitis, and found that even though both MET and corticosteroid injections improved measures of strength, pain, and function when assessed over 6-week, 26-week, and 52-week periods, MET showed better results long term [at 26-weeks and 52-weeks].[18] Another study used MET compared to static stretching to treat subacute mechanical neck pain. After 6 sessions of MET for one group, 6 sessions of static stretching for the second group, and a third group as a control, it was determined that though both the MET and stretching groups were effective at decreasing pain intensity and increasing active cervical range of motion when compared to the control group; however, the MET group showed superior results in comparison to the static stretching group.[19] MET has also been found to be just as effective or exhibiting similar improvements for ROM and other symptoms as low-level laser dosed at 200 ns and 6 J/cm[20], and Maitland mobilization.[21] These studies indicate that MET can also be useful if multiple sessions are used as part of a rehabilitation program.

One of the main confounding variables of this study was age. Although age was one of the quantitative variables of the study, it was thought that a subject's age may influence their range of motion because of the biological changes to the body occurs as one ages (i.e. muscle elasticity). However, there was a weak positive correlation between age and range of motion, nullifying that idea. Type of physical activity that each subject engages in also may be a confounding variable because the physiological demands of exercise may differ, and this study examined frequency of activity, and not type. For example, a subject who engages in weight training 4 days a week may have a variance in range of motion when compared to someone who participates in yoga 4 days a week.

Generalizability

The findings of this study suggest that MET may be an effective treatment that can be added to a rehabilitation regimen to help improve range of motion and treat muscular tightness. It can be used as a safe and effective tool for therapists to incorporate variety in programs, and possibly help in the process of returning a patient to full functionality due to its positive effect on ROM. MET is a useful tool also because it is a form of manual therapy; there is no equipment necessary for it to be utilized, so therapists in various settings can use this technique. MET is a simple and quick technique that can be completed within a couple minutes and can easily be implemented into a treatment regimen, before and even after a full rehabilitation session. Because MET is not a strenuous technique, it can be incorporated early within a rehabilitation protocol for an injury, such as an acute hip flexor strain. The effects of MET may be enhanced if paired with another modality, such as thermotherapy, which can be explored with further research. Another interesting notion is that MET can be applied in various ways (i.e. longer contraction times) and still yield improvements in patients[15], which is useful in creating variability in individual rehabilitation regimens. Future research should further assess the effect of MET of individuals with symptomatic hip flexor tightness or individuals with a history of hip surgery or trauma to the pelvic girdle or lower extremities.

References

1. Gillespie, C., & Bubnis, D. (2018). Tight Hips: 7 Stretches, Symptoms, Causes, Prevention, and More. Retrieved from https://www.healthline.com/health/tight-hips#stretches
2. Karunaharamoorthy, A., Becker, C. A., & Znotina, L. (2017). Iliopsoas Muscle. Retrieved November 9, 2017, from https://www.kenhub.com/en/library/anatomy/iliopsoas-muscle
3. Karunaharamoorthy, A., & Znotina, L. (2017). Quadriceps Femoris Muscle. Retrieved November 9, 2017, from https://www.kenhub.com/en/library/anatomy/the-quadriceps-femoris-muscle
4. Karunaharamoorthy, A., & Znotina, L. (2017). Sartorius Muscle. Retrieved November 9, 2017, from https://www.kenhub.com/en/library/anatomy/the-sartorius-muscle
5. Ergotron. (2013, July 17). New Survey: To Sit or Stand? Almost 70% of Full Time American Workers Hate Sitting, but They do it all Day Every Day. Retrieved November 19, 2017, https://www.prnewswire.com/news-releases/new-survey-to-sit-or-stand-almost-70-of-full-time-american-workers-hate-sitting-but-they-do-it-all-day-every-day-215804771.html
6. Gupta, D. S. (2016, January 28). How Can I Stay Safe on Ice? Retrieved April 21, 2017, from http://www.everydayhealth.com/news/how-can-stay-safe-on-ice/
7. Garnas, E. (2017, January 02). 5 Steps for Dealing with Anterior Pelvic Tilt. Retrieved April 21, 2017, from https://www.theptdc.com/2014/06/5-steps-dealing-anterior-pelvic-tilt/

8. Maduforo, C., West, O., Nwankwo, N., Onwuchekwa, R., Etawo, U. S., & Ogbulu, D. (2012). Study of the Lumbosacral Angles of Males in Port Harcourt, South- South, Nigeria. *The Nigerian Health Journal*, *12*(1), 22-24.
9. Holloway, B., Gotter, A., & Krucik, G. (2016, September 19). Muscle stiffness: Causes, Symptoms and Diagnosis. Retrieved December 18, 2017, from https://www.healthline.com/symptom/muscle-stiffness#modal-close
10. Johnson, J. (2012). *Therapeutic stretching*. Champaign, IL: Human Kinetics.
11. D'Ambrogio, K. (2012, May 11). PT Classroom - Muscle Energy Technique. Retrieved April 12, 2017, from http://www.cyberpt.com/muscleenergytechnique.asp
12. Lieber, R. L. (2010). *Skeletal muscle structure, function, and plasticity: the physiological basis of rehabilitation* (3rd ed.). Philadelphia, PA: Wolters Kluwer.
13. Somerset, D. (2016, December 28). Is Stretching the Hips a Bad Idea? Retrieved December 18, 2017, from https://www.theptdc.com/2015/11/why-doing-hip-flexor-stretches-may-not-loosen-and-open-up-the-hips/
14. Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.
15. Smith, M., & Fryer, G. (2008). A comparison of two muscle energy techniques for increasing flexibility of the hamstring muscle group. Journal of Bodywork and Movement Therapies,12(4), 312-317. doi:10.1016/j.jbmt.2008.06.011
16. Lenehan, K.L., Fryer, G. & McLaughlin, P. (2003) The effect of muscle energy technique on gross trunk range of motion. *Journal of Osteopathic Medicine 6*(1), 13-18.

17. Moore, S. D., Laudner, K. G., Mcloda, T. A., & Shaffer, M. A. (2011). The Immediate Effects of Muscle Energy Technique on Posterior Shoulder Tightness: A Randomized Controlled Trial. *Journal of Orthopaedic & Sports Physical Therapy, 41*(6), 400-407. doi:10.2519/jospt.2011.3292

18. Küçükşen, S., Yilmaz, H., Sallı, A., & Uğurlu, H. (2013). Muscle Energy Technique Versus Corticosteroid Injection for Management of Chronic Lateral Epicondylitis: Randomized Controlled Trial With 1-Year Follow-up. *Archives of Physical Medicine and Rehabilitation*, *94*(11), 2068-2074. doi:10.1016/j.apmr.2013.05.022

19. Mahajan, R., Kataria, C., & Bansal, K. (2012). Comparative Effectiveness of Muscle Energy Technique and Static Stretching for Treatment of Subacute Mechanical Neck Pain. *International Journal of Health and Rehabilitation Sciences (IJHRS),1*(1), 16-24. doi:10.5455/ijhrs.00000004

20. Akbari, A., Naroii, S., Eshgi, M., & Farahani, A. (2012) A Comparison between Muscle Energy Technique with Low-Level Laser in Reducing Neck and Shoulder Pain and Disability in Subjects with Trapezius and Levator Scapula Myofascial Trigger Points. *ZUMSJ, 20*(79), 69-82

21. Suir, S.A. & Anand, M. (2013). Comparative Study on the effectiveness of Maitland Mobilization Technique Versus Muscle Energy Technique in Treatment of Shoulder Adhesive Capsulitis. *Indian Journal of Physiotherapy and Occupational Therapy, 7*(4), 1-6

Tables and Figures

Table 1

Gender Differences in Mean Passive Hip Extension ROM

Gender	Age (years)	ROM-B	ROM-P	ROM-24P
Female (n = 31)	23.35 ± 5.64	13.68 ± 4.75°*+	17.87 ± 5.04°*	17.55 ± 5.18°+
Male (n = 22)	24.14 ± 3.77	12.46 ± 5.26°*+	16.68 ± 5.23°*	16.68 ± 5.23°+
All (n= 53)	23.75 ± 4.71	13.07 ± 5.01°*+	17.28 ± 5.14°*	17.12 ± 5.21°+

ROM-B = Baseline passive hip extension ROM
ROM-P = Post-MET passive hip extension ROM
ROM-24P = 24-hours Post-MET passive hip extension ROM
*There was a significant difference between ROM-B and ROM-P ($p = .000$, $p < 0.05$).
+There was a significant difference between ROM-B and ROM-24P ($p = .000$, $p < 0.05$).

Table 2

Physical Activity Frequency Differences in Mean Passive Hip Extension ROM

P.A.F.	Age (years)	ROM-B	ROM-P	ROM-24P
Light (n = 20)	22.25 ± 4.51	12.30 ± 4.01°*+	16.40 ± 3.90°*	16.35 ± 3.66°+
Mod. (n = 33)	24.55 ± 5.03	13.70 ± 5.44°*+	17.97 ± 5.69°*	17.69 ± 5.89°+
All (n = 53)	23.40 ± 4.77	13.00 ± 4.73°*+	17.19 ± 4.80°*	17.02 ± 4.78°+

P.A.F. = Physical Activity Frequency
ROM-B = Baseline passive hip extension ROM
ROM-P = Post-MET passive hip extension ROM
ROM-24P = 24-hours Post-MET passive hip extension ROM
*There was a significant difference between ROM-B and ROM-P ($p = .000$, $p < 0.05$).
+There was a significant difference between ROM-B and ROM-24P ($p = .000$, $p < 0.05$).

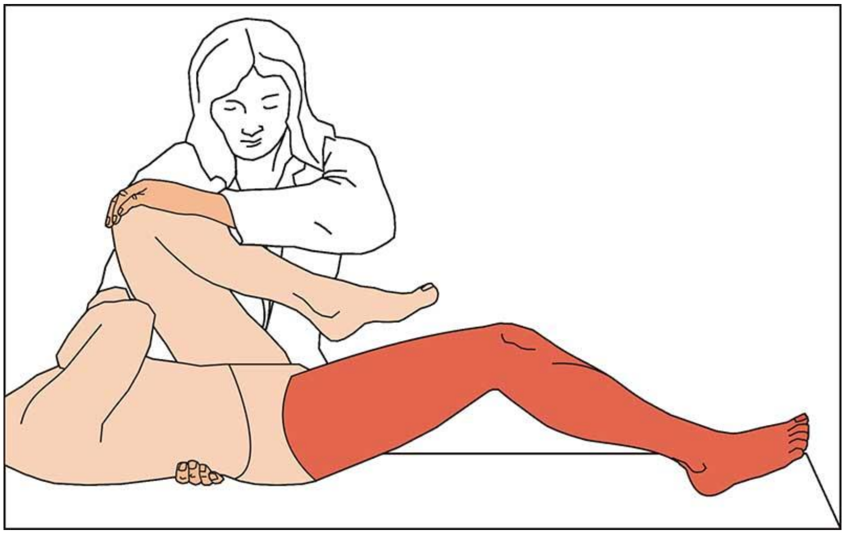


Figure 1. An example of the Thomas test, performed by the therapist. Source: https://clinicalgate.com/61-total-hip-replacement/

Figure 2. An example of performing muscle energy technique. The therapist's position, and the therapist's motion to counteract the patient indicated by the downward arrow. The patient's correct positioning, and the patient's motion indicated by the upward arrow. Source: https://positivehealth.com/muscle-energy-techniques-mets-applied-to-knee-pain

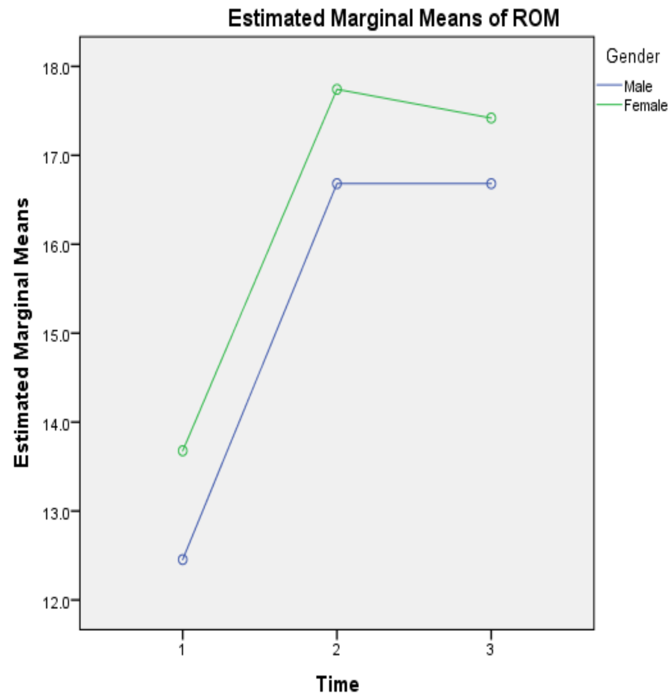


Figure 3. There was no significant interaction of mean passive hip extension ROM over time (1 = baseline, 2 = post, and 3 = 24-hours post) between males and females ($p > 0.05$).

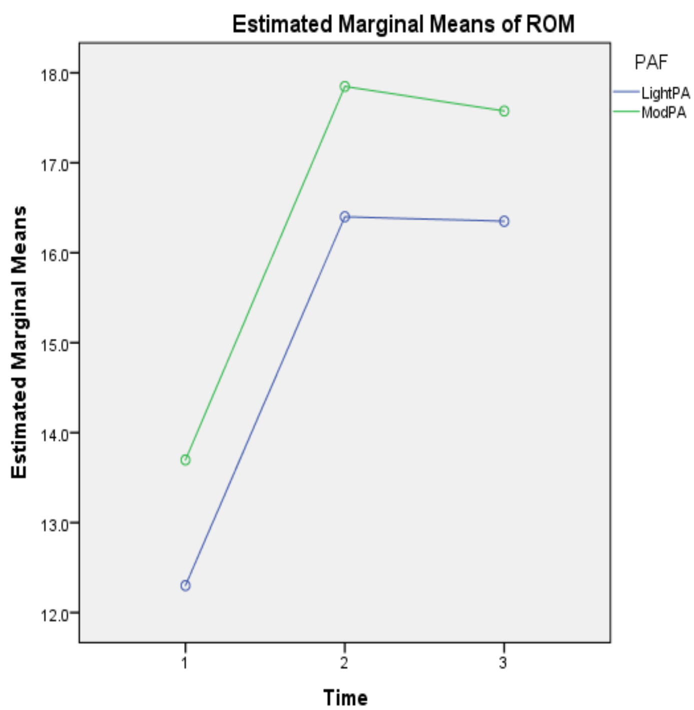


Figure 4. There was no significant interaction of mean passive hip extension ROM over time (1 = baseline, 2 = post, and 3 = 24-hours post) between light physical activity and moderate physical activity ($p > 0.05$).

APPENDIX A

Subject Information Packet

The Hip Flexor Muscle Group

The three muscles shown om Figure A1 make up the hip flexor muscle group: the rectus femoris, sartorius, and iliopsoas. They all play a role in hip flexion. The green dot shows their common location and muscular attachment points on the pelvis. These muscles can become tight, shortened, and weakened by prolonged sitting for extended periods of time. Hip flexor tightness involves one, if not all, of these muscles and can cause other musculoskeletal issues.

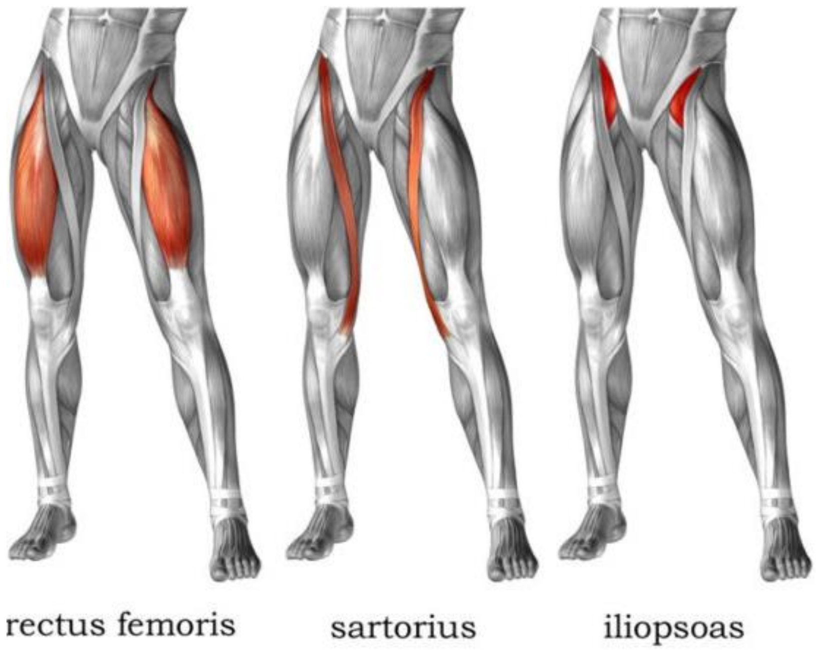
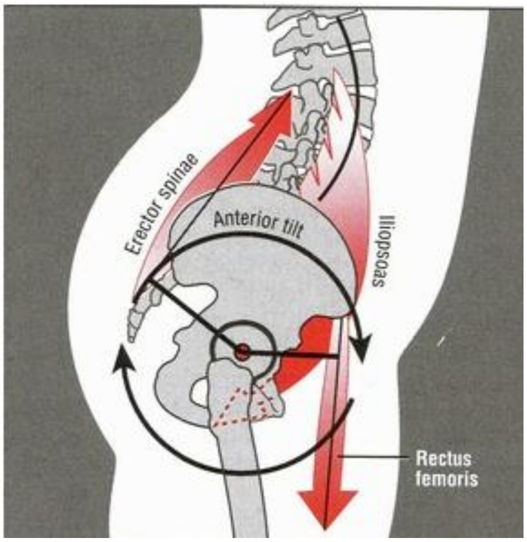


Figure A1. A depiction of the main muscles of the hip flexor muscle group. Source: https://www.otpbooks.com/mike-boyle-hip-flexion/

Impending Effects of Hip Flexor Tightness

When hip flexor tightness is present, the muscles of the hip flexor group are in a shortened state. These shortened muscles create an anterior pull on the pelvis, eventually leading to an anterior pelvic tilt, as shown in Figure A2. This anterior pelvic tilt is poor posture, and places pressure on lumbar vertebrae and facet joints, which can cause pain and other pathologies associated with the pelvis and the vertebral column (Figure A3).

(2)



(3)

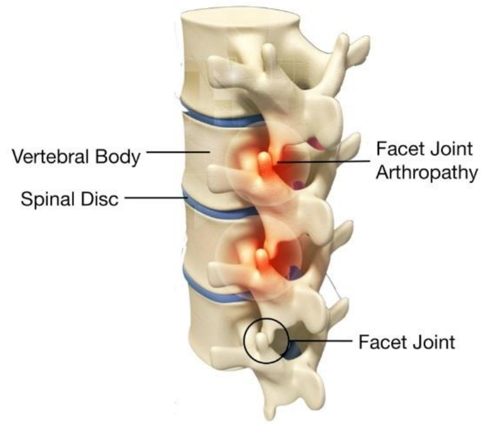


Figure A2. A depiction of the biomechanical change that is brought upon the musculoskeletal system when hip flexor tightness leads to anterior pelvic tilt. Source: https://dailyhealthpost.com/anterior-pelvic-tilt/

Figure A3. The components of the vertebral column that may be affected by hip flexor tightness and ultimately anterior pelvic tilt. Source: https://walterroadchiropractic.com.au/morley/lumbosacral-facet-syndrome/

The Thomas Test

To assess if hip flexor tightness is present, the Thomas test will be performed, as shown in Figure A4 below. One side will be pulled/pushed into hip flexion while the other side is remains relaxed. If the opposite, and relaxed, leg raises up off the table, the hip flexor muscles are tightened and shortened.

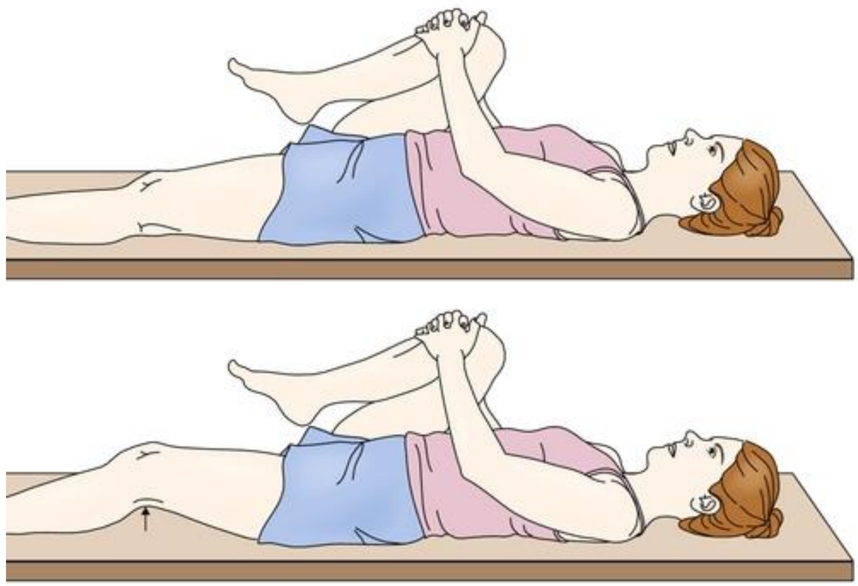


Figure A4. The Thomas test, performed by the patient. Source: https://clinicalgate.com/61-total-hip-replacement/

Measuring Passive Hip Extension

Range of motion for hip extension will be measured passively. The positioning for this measurement is shown in below in Figure A5. The subject is lying prone, holding the uninvolved leg in flexion, or with the therapist holding the uninvolved leg in flexion. The subject is to remain relaxed, allowing the involved limb to hang off the table, without any movement or muscular activity. A goniometer will be used for measurement (Figure A6).

Figure A5. Example of patient and therapist position to measure passive hip extension. Source: https://www.researchgate.net/publication/295831231_Spinal_alignment_mobility_of_the_hip_and_thoracic_spine_and_prevalence_of_low_back_pain_in_young_elite_cross-country_skiers/figures?lo=1

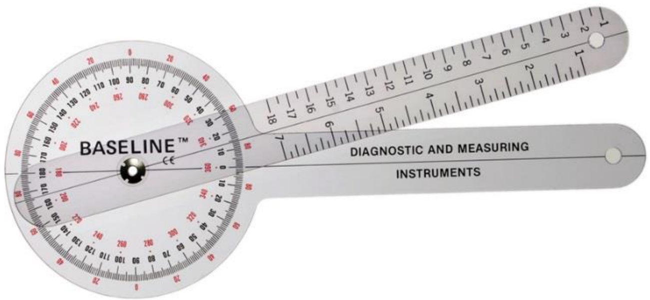


Figure A6. A 12-inch goniometer. Source: https://www.tensnet.com/Baseline-Plastic-Goniometer-360-Degree-Head-12-inch-Arms.html

Performing Muscle Energy Technique

Muscle energy technique is a series of 3 to 5 repetitions of 10-second isometric contractions. This technique can help relieve muscular tightness and improve range of motion, or flexibility. Figure A7 depicts the patient position: lying supine on a table, with one leg pressed up againtst the therapist, and the other hanging off the table. The therapist will have one hand on the hip and the other right above the knee. The patient will push up with their thigh, into the therapist's hand with a light, yet firm effort. Figure A8 shows the therapist's position relative to the patient. The therapist pushes down to counter the patient's motion. After the repetition is complete, the therapist pushes the patient further into a stretch for about 3 to 5 seconds, starting the next rep.

Figure A7. The patient's correct positioning, and the patient's motion indicated by the red arrow. Source: https://positivehealth.com/muscle-energy-techniques-mets-applied-to-knee-pain

Figure A8. The therapist's position, and the therapist's motion to counteract the patient indicated by the red arrow. Source: https://positivehealth.com/muscle-energy-techniques-mets-applied-to-knee-pain

APPENDIX B

Health and Demographics Questionnaire

Participant ID (First Initial, Gender Code, Mother's Initials, Day of Birth):

____

Date: ______/______/______ **Age**: ______

Gender (Circle One): Male Female

How often do you participate in physical activity? (Check ONE):

- ☐ 1 – 3 days a week
- ☐ 4 or more days a week

Have you had a surgical procedure in the past 12 months? (Circle One): Yes No

If yes, explain: ____
____
____

Are you taking any medications? (Circle One): Yes No

If yes, explain: ____
____
____

FEMALES ONLY: Are you currently pregnant? (Circle One): Yes No

Have you ever experienced any of the following conditions? Check all that apply.

☐ Heart Disease	☐ Hight Cholesterol (>240)	☐ Hernia
☐ Rheumatic Disease	☐ High Blood Pressure	☐ Cancer
☐ Angina/Chest Pain	☐ Heart Murmurs	☐ Arthritis
☐ Heart Attack	☐ Stroke	☐ Lung Disease (asthma, etc.)
☐ Severe Back Pain	☐ Severe Hip/Pelvic Pain	☐ Seizure/Epilepsy
☐ Faint Spells	☐ Diabetes	☐ Irregular Heartbeat
☐ Neuropathy	☐ Joint, Tendon, or Muscular Pain	☐ Other

Other conditions not listed: ____
____
____

Explain any conditions you checked: ____
____
____

I have answered all the above questions truthfully and all the above information is attributed to me. I was informed that this information will only be accessible to the researcher and will be held in confidence. I am aware that I may be included or excluded from the study based on the answers to the above questions. If any of the above information was falsely reported and led to an adverse effect after the procedures, I am fully liable and responsible for such occurrences.

Participant's ID: _______________

Researcher's Signature: ____________________

APPENDIX C

Barry University Informed Consent Form

You are about to participate in a research study. The name of the study being conducted is **The Effect of Muscle Energy Technique on Hip Flexor Tightness**. This research study is being conducted by Victoria Noel, a graduate student of the Sport and Injury Biomechanics program in the College of Nursing and Health Sciences at Barry University, in Miami Shores, Florida. The purpose of the study is to determine and examine the immediate effects of the Muscle Energy Technique on hip flexor tightness and hip range of motion.

To participate in this study, subjects must be 18 – 50 years old and physically active for at least 30 minutes a day at least once a week. Subjects will be obligated to complete and sign this consent form and a health questionnaire before participating in the study. In addition to this informed consent form and the health and demographics questionnaire, you will receive access to a detailed information packet with images to explain the purpose and procedures of the study. The health and demographics questionnaire is a survey of health status and frequency of engagement in physical activity. The questionnaire serves to ensure general well-being and no history nor current implications of severe disease, neuromuscular disorders, and musculoskeletal pathologies. Subjects will be excluded if they have a chronic health issue. **Subjects will participate in two sessions.** First, each subject will be evaluated by the Thomas test to check for hip flexor tightness. The Thomas test involves the patient lying supine, and having one leg relaxed, while the opposite leg is placed into knee and hip flexion by the therapist. If the knee of the relaxed side bends and lifts off the table, then the patient is positive for hip flexor tightness. Subjects will face exclusion from the study if they are found negative for the Thomas test for hip flexor tightness. If found positive, the subjects' passive range of motion for hip extension will be measured with a 12-inch goniometer to establish a baseline. Passive ROM of hip extension can be assessed with the patient supine and the leg hanging from the table, allowing gravity to pull the leg down allowing for the absence of any active muscular contractions by the patient.

Then, each subject will receive a single application of muscle energy technique (MET), followed by a post-intervention range of motion measurement. MET involves the use of light voluntary isometric contractions to reset the proprioceptors within muscle. MET is initiated by having the subject lay supine with the untreated limb relaxed, and the limb to be treated hanging off the treatment table. The therapist will be standing beside the subject, with one hand stabilizing on the hip and the other hand placed right above the knee, of the side to be treated. The therapist will manually find a restriction in the muscle on the side to be treated by moving the subject gently into passive hip extension. Then, the subject will perform a voluntary isometric contraction of the hip flexors by bringing the knee up against the therapist's hand, eliciting a firm yet light contraction. This contraction will be held for ten seconds then immediately followed by five seconds of relaxation; this pattern will be repeated for five repetitions. After each repetition, the therapist will put the patient slightly further into a stretch to find a new point of resistance, without producing pain. Each subject will receive one application of MET: five repetitions of 10-second isometric contractions.

The first session should be approximately 45 minutes in duration, which involves the use of the Thomas test, pre-invention ROM measurements, a single application of MET, and post-intervention ROM measurements. 24 hours post-intervention, subjects will return to the lab for a third range of motion measurement. **No intervention will be administered at this second meeting; thus, the duration of the second meeting should be no more than 20 minutes. The total time for this study is approximately 1 hour, over the course of two days.** A certified and licensed athletic trainer will perform the Thomas test, all range of motion measurements, and the muscle energy technique intervention, which are all common duties from within the scope of practice of an athletic trainer.

Your participation in this research is voluntary. At any time during the study, or prior to it, you may decline or reconsider participation, without penalization. Although there are no direct benefits for the individuals who participate in the study, there is currently a lack of evidence on the use of muscle energy technique on the hip flexor muscle group. It is anticipated, the results of this study will lead to further support and discovery of effective treatment protocols for injury prevention and management amongst physically active individuals with hip flexor tightness and other related conditions. There are **no known risks** to participating in this study. Whenever voluntarily contracting a muscle, muscle soreness is a possible side effect; however, according to current literature, muscle soreness has never been reported after intervention of muscle energy technique. Any possible side effects can be greatly minimized when MET is delivered by a licensed and certified clinician, such as an athletic trainer. Subjects are encouraged to report any and all symptoms, sensations, and feedback to the researcher.

As a participant in this study, **all information is confidential**. No subject will be identifiable by the information they provide. Each subject will receive a random numerical code that will simply be used to match pre-test and post-test data. All data will be saved on a password-protected laptop and stored in a closed, locked administrative office. The informed consent form and the health and demographics questionnaire will be collated separately into folders and stored in a locked file cabinet. No photos of the subjects will be taken or used at any time. If the results of this study are published, the data that is referenced will be group averages and will not refer to a subject by name. Data will be kept in the primary researcher's possession for a minimum of 5 years upon completion of the study. Since the subjects' will have coded IDs, the data collected cannot be traced back to participants.

If you would like to participate or have any questions or concerns regarding the study or your participation in the study, you may contact me, Victoria Noel at (954)-461-1934 or e-mail victoria.noel@mymail.barry.edu, my supervisor Dr. Meredith Parry, at (305)-899-1176 or e-mail mparry@barry.edu, or the Institutional Review Board point of contact, Jasmine Trana, at (305)899-3020 or e-mail jtrana@barry.edu.

Please confirm your consent below:

I have been properly educated and informed of the purpose of this study. I have fully read and understand all contents provided and have a personal copy. I will ensure that all answers to questions and participation of this study from myself will be honest and true. I give consent to participate.

Participant ID: ______________________ Date: ____________________