

The Effect of Instrument Assisted Soft Tissue Mobilization on Iliotibial Band Extensibility and Hip Abduction Strength.

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TABLE OF CONTENTS

	PAGE
TABLE OF CONTENTS.....	2
ABSTRACT	4
MANUSCRIPT	6
Title: The Effect of Instrument Assisted Soft Tissue Mobilization on Iliotibial Band Extensibility and Hip Abduction Strength.	
LIST OF FIGURES	21
Figure 1. Hip Adduction ROM Measurement.....	22
Figure 2. Hip Abduction Strength Measurement	23
Figure 3. Pain and Function Visual Analog Scale.....	24
Figure 4. Graston Technique Instruments.....	25
Figure 5. Hip Adduction ROM Results.....	26
Figure 6. Hip Abduction Strength Results.....	27
APPENDIX A	29
Operational Definitions, Assumptions, Delimitations, Limitations, Statement of Problem, Research Hypothesis, Null Hypothesis	
APPENDIX B	35
Review of Literature	

Accepted by the Graduate Faculty, Indiana University, in partial fulfillment of the requirements for the degree Master of Science in Kinesiology.

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ABSTRACT

The purpose of this investigation was: 1) to determine if Graston Technique (GT) is effective in increasing hip adduction ROM and 2) to determine if GT is effective in increasing hip abduction strength. Prior to beginning the study all subjects were pseudo-randomly assigned by gender in either the Graston Technique (9 males and 13 females; $19.59 \pm .96$ yrs; 172.20 ± 11.36 cm; 69.17 ± 13.27 kg) or control group (10 males and 13 females; 19.13 ± 1.01 yrs; 170.85 ± 8.55 cm; 65.76 ± 10.29 kg). Normative values for ITB flexibility is 10-26 degrees.²² Subjects with less than 26 degrees of hip adduction were identified as “at risk” due to their predisposition to ITB related pathology. Subjects were then randomly assigned to the GT or sham microcurrent group. Subjects in the GT group underwent a warm-up, GT instrumentation, and strengthening exercises. The sham microcurrent group underwent a no intensity microcurrent treatment which served as the control condition. Means and standard deviations of hip adduction ROM and hip abduction strength was calculated for the three trials on 4 testing days (Pre treatment, after 1 week of treatment, immediately post treatment, and 1 month follow up). Four repeated mixed factor measure analysis of variance were completed, one for each dependent variable. The analyses included one between subjects factor (group at 2 levels) and one within subjects factor (time at 4 levels). Bonferroni post hoc testing was completed on all significant findings. A priori alpha level will be $p < .05$. Results of the repeated measures ANOVA identified a significant time by group interaction for hip abduction strength ($F_{3,129} = 3.06$, $p = .03$, $\eta_p^2 = .07$, power = .71). Following the post hoc test, we identified that the GT group had significantly more force production from baseline to post treatment (mean difference: $1.57 \pm .45$; $p = .01$; 95% CI: .32 to 2.83), from baseline to 1 month follow up (mean difference: $1.88 \pm .45$; $p = .01$; 95% CI: .64 to 3.13), and from mid treatment to post treatment (mean difference: $1.26 \pm .34$; $p = .01$; 95%

CI: .32 to 2.21). No significant time by group interaction was identified for hip adduction ROM, pain, or function. Results of this study indicate that after six treatment sessions, subjects in the GT group improved hip abduction strength. Furthermore, the increase in strength continued at the one-month follow up. As no treatment was performed between the post treatment measurement and one month follow up, we believe that the IASTM application was effective in decreasing soft tissue restrictions to provide a more functional contractile unit. By decreasing soft tissue restrictions in the gluteal region, TFL, and throughout the length of the ITB, the muscle fibers could align in a more optimal position. While there was no significance between the GT group and control group in hip adduction ROM, an upward trend was seen, especially at the one month follow up in the GT group. As ROM continued to increase after the end of treatment, it is possible that the effects of IASTM could be long lasting. The continuance of increasing ROM with no treatment indicates that the IASTM potentially decreased soft tissue adhesions and elongated the entire ITB unit.

INTRODUCTION

Tightness of the iliotibial band (ITB) is common amongst the active population, especially runners and cyclists, predisposing them to ITB related pathologies such as iliotibial band friction syndrome (ITBFS) and patellofemoral pain syndrome (PFPS).¹⁻⁴ The ITB lies anterior to the lateral femoral condyle when the knee is in full extension, however, when flexed to 30 degrees; the gluteus maximus pulls the ITB posteriorly to lie on top of the femoral condyle. As this process repeats itself during running or cycling, friction between the lateral femoral condyle and ITB insertion occurs, resulting in an inflammatory response. This inflammation can cause an increase in pain, decrease in function, and decreased extensibility of the ITB.

Treatment options for pathologies related to ITB tightness focus on management of signs and symptoms and the elimination of inflammation.⁵ Non-steroidal anti-inflammatory drugs and corticosteroid injections are commonly administered in conjunction with activity modification to decrease inflammation.⁵ Therapeutic exercise is directed towards increasing hip abduction strength⁶⁻⁹ and ITB extensibility.^{10, 11} Hip abduction isotonic and isokinetic strengthening exercises as well as various stretching protocols have been shown to decrease pain, increase tissue extensibility, and improve function.^{6-10, 12} However, due to the multiple layers and firm longitudinal attachment of the ITB to the femur, changes in hip adduction ROM are thought to be caused from an apparent lengthening of the tensor fascia latae (TFL) rather than a functional lengthening of the ITB.^{5, 11} As soft tissue mobilization has the potential to reduce fascial restrictions and muscular stiffness, application could provide a functional lengthening of the ITB and associated musculature more efficiently and effectively than stretching alone.⁵

Soft tissue mobilization (STM) is a broad term for the manipulation of soft tissue structures to release adhesions and increase soft tissue extensibility. Various forms of STM exist

including massage, muscle energy, trigger point therapy, and active release technique. This study will focus on a specific soft tissue approach called instrument assisted soft tissue mobilization (IASTM), specifically Graston Technique (GT).

GT is a form of soft tissue mobilization that uses six patented stainless steel instruments to diagnose and treat soft tissue adhesions and fascial restraints.¹³ GT is a comprehensive, five phase protocol comprised of a cardiovascular warm-up, GT instrument application, targeted stretches, low-load high repetition exercises, and cryotherapy.¹³ Various benefits have been demonstrated from GT treatment, however, the majority of the research is in the form of case studies. GT has been reported to decrease pain,¹⁴⁻¹⁸ increase range of motion,^{14-16, 19, 20} and increase function^{14-18, 20, 21} in both acute and chronic conditions. However, no published studies evaluate the effectiveness on the treatment of the ITB. Therefore, the purpose of this investigation is to determine if a specific form of soft tissue mobilization, Graston Technique, affects ITB extensibility, hip abduction strength, and self-perceived pain and function.

METHODS

Subjects

Forty-five subjects from a large university and high school volunteered for this study. Participants were screened for ITB mobility by assessing hip adduction ROM, prior to the beginning of the study. Normative values for ITB flexibility is 10-26 degrees.²² Subjects with less than 26 degrees of hip adduction were identified as “at risk” due to their predisposition to ITB related pathology. Before participating in the study, all participants read and signed an informed consent form approved by the University’s Institutional Review Board for the Protection of Human Subjects, which also approved the study.

Procedures

Prior to beginning the study all subjects were pseudo-randomly assigned by gender in either the Graston Technique (9 males and 13 females; $19.59 \pm .96$ yrs; 172.20 ± 11.36 cm; 69.17 ± 13.27 kg) or control group (10 males and 13 females; 19.13 ± 1.01 yrs; 170.85 ± 8.55 cm; 65.76 ± 10.29 kg) to ensure homogeneity in baseline numbers. The right leg was arbitrarily chosen for treatment with all subjects. All subjects received six days of treatment, with 48-72 hours between sessions. All subjects underwent ROM, strength testing, and perceived pain and function testing 4 times (baseline, after 3 treatment sessions (mid), after 6 treatment sessions (post), and a one month follow-up). One researcher performed all measurements and another researcher performed all the treatments. The researcher performing the measurements was blinded from group assignments and the researcher performing the treatments was blinded from measurement results. The subjects were instructed to not perform any type of soft tissue mobilization or stretching techniques to the right ITB throughout the testing period.

ROM Testing

First, the inclinometer, Acumar Digital Inclinometer (Lafayette Instrument Company, Lafayette, Indiana), was zeroed on a known level surface. Subjects were positioned side lying on left leg with the left hip and knee bent to 45 degrees and 90 degrees, respectively, for stabilization. The subject's pelvis was aligned and rested on a wood support positioned perpendicular to table. (Figure 1) The examiner assisted in the stabilization by placing a hand on the pelvis, which allowed for the detection of any anterior/posterior motion. The subject's position was intent on limiting unwanted pelvic or trunk motion while testing. The examiner instructed the subject to remain relaxed and passively flex, abduct, and extend the hip until motion stopped due to tissue tightness or motion at the pelvis.

The examiner provided support at the medial joint line of the knee during passive adduction. The end range was reached when either hip adduction stopped or movement at the pelvis occurred. Upon reaching the end position, hip adduction was measured by a digital inclinometer. The inclinometer was placed on the subject's lateral leg over the ITB half way between the greater trochanter and lateral knee joint line. Three trials were performed and data was sent directly to the computer using the Acumar IR Wireless Computer Interface (Lafayette Instrument Company, Lafayette, Indiana).

Strength Testing

During the strength testing, the subject was positioned the same during the ROM testing. The examiner placed a hand over the subject's iliac crest for support. Then, the examiner instructed the subject to slightly extend and abduct leg to 30 degrees to isolate the gluteus medius.²³

The examiner placed the hand with the Lafayette Manual Muscle Test System (Lafayette Instrument Company, Lafayette, Indiana) just superior to subject's lateral malleolus. The examiner instructed the subject to maximally contract against the pad of the hand-held dynamometer (HHD) in an abduction direction while the examiner stabilized the HHD to maintain an isometric contraction (Figure 2). Force, in kilograms (kg), was measured and digitally saved. Three trials were performed, with a 30 second rest in between trials to prevent muscle fatigue. Maximal hip abductor strength was normalized to each subject's weight.

Visual Analog Scale

Subjects also completed a Visual Analog Scale (VAS) for pain and function prior to and after treatment each day. Two 10 cm vertical lines for both pain and function was used. Subjects were asked for a current pain level rated between "pain as bad as it could be" representing a 10

and “no pain at all” representing a 0. Subjects were also asked current functional level rated between “no physical limitations” representing a 10 and “too painful to do anything” representing a 10 (Figure 3). Subjects placed a mark at their perceived pain and function level. The examiner then measured the mark with a metric ruler and established a quantitative value between 0 and 10. Results were measured to the nearest millimeter. The pain and function scales were reversed on the page from ascending to descending to eliminate any subject bias.

Treatment

Graston Technique

Subjects ran on a treadmill at 5 MPH for 5 minutes to actively warm up the targeted tissues. Subjects were positioned in a side-lying position on their non-treatment leg. The treatment leg was positioned in full extension while the non-treatment leg was flexed at hip and knee at 45 degrees and 90 degrees, respectively for stability. Emollient was applied to the leg from the lateral joint line and tibial condyle to just inferior to the iliac crest. Instruments GT-1, GT-3, and GT-4 were used in treatment (Figure 4). The GT-1 instrument was used to assess the soft tissue of the lateral leg in three segments: anterior to the ITB, directly over the ITB, and posterior to the ITB. The convex GT-4 instrument was then used with sweeping and fanning strokes to the tissues in the same area. The GT-3 instrument was used to treat the ITB insertion at Gerdy’s Tubercle and the lateral patellar retinaculum with brushing and strumming strokes. Immediately following, the GT-3 instrument was used to frame the greater trochanter, a technique specific to address large bony and soft tissue interfaces. The tensor fascia lata was then treated with the GT-3 instrument with strumming and brushing strokes. Immediately following, two low load exercises were performed for 2 sets of 20 repetitions with a 30 second rest between each set. The first exercise was side-lying hip abduction with 15 degrees of flexion with the leg

externally rotated. The second exercise was side-lying hip abduction to 30 degrees with the hip extended. Patient would then externally rotate leg, internally rotate it and return back to neutral, then lower the leg back to the resting position.

Control Group

Subjects assigned to the control group were placed in a side-lying position on the non-treatment leg. The treatment leg was fully extended while the subject's non-treatment leg was flexed at the hip and knee at 45 degrees and 90 degrees, respectively, for stability. Subjects in the control group received a sham microcurrent treatment. Adhesive electrodes were applied over the greater trochanter and just above the lateral knee joint line. The electrodes were plugged into the machine and turned on, but intensity was not increased. Subjects were instructed that they should not expect to feel anything during the treatment.

Statistical Analysis

Means and standard deviations for hip adduction ROM and hip abduction strength were calculated for the three trials on all test days. Pain and function data was evaluated on all test days via the VAS and assigned a quantitative value for analysis. Four repeated measure analysis of variance were completed, one for each dependent variable. The analyses included one between subjects factor (group at 2 levels) and one within subjects factor (time at 4 levels). Post hoc test was completed on all significant findings. A priori alpha levels were set at $p < .05$.

RESULTS

Strength

Means and standard deviations for each group can be found in Table 1. Results of the repeated measures ANOVA identified a significant time by group interaction for hip abduction strength ($F_{3,129} = 3.06$, $p = .03$, $\eta_p^2 = .07$, power = .71). Following the post hoc test, we identified

that the GT group had significantly more force production between baseline and post treatment (mean difference: $1.57 \pm .45$; $p = .01$; 95% CI: .32 to 2.83), between baseline and 1 month follow up (mean difference: $1.88 \pm .45$; $p = .01$; 95% CI: .64 to 3.13), and between mid treatment and post treatment (mean difference: $1.26 \pm .34$; $p = .01$; 95% CI: .32 to 2.21). No changes were found in the control group.

Range of Motion

Means and standard deviations for each group can be found in Table 1. Results of the repeated measures ANOVA identified no significant time by group interaction for hip adduction ROM ($F_{3,129} = 1.86$, $p = .14$, $\eta_p^2 = .04$, power = .47). We identified a main effect for time ($F_{3,129} = 6.33$, $p = .01$, $\eta_p^2 = .13$, power = .96). Following the post hoc test, we identified that both groups had significantly more ROM from baseline to post treatment (mean difference: $2.44 \pm .80$; $p = .01$; 95% CI: 0.44 to 4.44) and from baseline to 1 month follow up (mean difference: $3.19 \pm .79$; $p = .01$; 95% CI: 1.02 to 5.36). There was no main effect for group identified ($F_{1,43} = .95$, $p = .33$, $\eta_p^2 = .02$, power = .16).

Pain

Means and standard deviations for each group can be found in Table 1. Results of the repeated measures ANOVA identified no significant time by group interaction for pain via the VAS ($F_{3,129} = .39$, $p = .76$, $\eta_p^2 = .01$, power = .09). There was no main effect for time identified ($F_{3,129} = .22$, $p = .88$, $\eta_p^2 = .01$, power = .09). Furthermore, there was no main effect for group identified ($F_{1,43} = 1.59$, $p = .22$, $\eta_p^2 = .04$, power = .23).

Function

Means and standard deviations for each group can be found in Table 1. Results of the repeated measures ANOVA identified no significant time by group interaction for function via

the VAS ($F_{3,129} = .49$, $p = .69$, $\eta_p^2 = .01$, power = .15). There was no main effect for time identified ($F_{3,129} = .35$, $p = .79$, $\eta_p^2 = .01$, power = .12). Furthermore, there was no main effect for group identified ($F_{1,43} = 2.48$, $p = .12$, $\eta_p^2 = .05$, power = .34).

DISCUSSION

After six treatment sessions, subjects in the GT group improved hip abduction strength. Furthermore, the increase in strength continued at the one-month follow up. However, no statistically significant change was seen in regards to hip adduction ROM or VAS scores for pain and function between the GT group and control group.

Strength

The largest gains in strength occurred between the mid treatment and post treatment measurements. This indicates that low-load, high-rep hip abduction active exercises were successful at targeting the gluteus medius muscle. Furthermore, the gains continued to increase after cessation of treatment at the one month follow up. As no treatment was performed between the post treatment measurement and one month follow up, we believe that the IASTM application was effective in decreasing soft tissue restrictions to provide a more functional contractile unit. By decreasing soft tissue restrictions in the gluteal region, TFL, and throughout the length of the ITB, the muscle fibers could align in a more optimal position. This could result in a more functional unit as the ITB serves as the insertion of the gluteus maximus. Furthermore, hypertonic muscles can result in soft tissue restrictions and impair efficient muscular function. By relieving the soft tissue restrictions and relaxing hypertonic muscles, it is possible to achieve a stronger contraction and thus increase strength.

Recent studies⁷⁻⁹ evaluating the effectiveness of hip abduction strengthening protocols have reported similar increases. Previous studies have performed hip abduction strengthening exercises for three to six weeks,⁷⁻⁹ significantly longer than our treatment window of only two weeks. Studies evaluating a six week hip abduction strengthening protocol have reported an increase of 34.9% - 51.4%⁷ of maximal isometric hip abduction along with an increase in electromyography of gluteus medius.⁹ Three weeks of hip abduction strengthening have reported increases of 32.7% as compared to a control group.⁸ Our study yielded a 12.15% increase from baseline to post treatment and 15.25% increase from baseline to one-month follow up. Although our increases were not as substantial, our treatment window was significantly shorter and exercise frequency was lower. Furthermore, progressive overload was not applied as the focus of the hip abduction exercises was to apply a direction of force to aid in the optimal alignment of collagen fibers.

Range of Motion

While there was no statistically significant difference between the GT and control groups in hip adduction ROM, an upward trend was seen in the GT group, especially at the one month follow up. As ROM continued to increase after the end of treatment, it is possible that the effects of IASTM could be long lasting. The continuance of increasing ROM with no treatment indicates that the IASTM potentially decreased soft tissue adhesions and elongated the entire ITB unit. Furthermore, the timeline for improvement at the one month follow up is consistent with the timeline of the healing cascade. GT is theorized to initiate a controlled and localized inflammatory process to allow for the healing of damaged tissues. The one month follow up could have allowed for the synthesis and proliferation of collagen to occur and the proliferation phase of healing to conclude.

However, the magnitude of the impact that an IASTM application can create may be limited due to the dense, layered structure and firm attachments that the ITB has throughout the length of the femur. Cadaveric dissection has revealed that the ITB is connected to the linea aspera of the femur from the greater trochanter to the lateral epicondyle by fibrous bands at an average thickness of 0.3 mm.⁵ No studies have evaluated the efficacy of IASTM on ITB extensibility, but a study¹⁹ evaluating the effectiveness of GT on carpal tunnel syndrome indicated an increase in wrist ROM. After ten GT treatments, subjects increased wrist extension ROM by 7.3° and wrist flexion by 7.2°. However, wrist musculature that was targeted with GT treatment does not have multiple layers or is as fibrous as the ITB and has better potential for ROM gains.

Studies evaluating an increase in ITB extensibility through stretching focused on the immediate effects of hip adduction ROM as they assessed immediately following treatment. Average changes in ITB length during stretching ranged from 9.84% to 11.15% of resting length.¹⁰ These changes found through stretching were not long lasting and were potentially due to elongation and relief of muscular tightness of the TFL and gluteus maximus, rather than increasing the true length of the ITB. As the ITB is not a contractile tissue, the potential for it to be affected by stretching is minimal. Thus, the elongation that has been observed through an increase in hip adduction ROM is better explained by elongation of the TFL and gluteus maximus rather than elongation of the ITB.

Pain and Function

As the focus of the study was preventative in nature and we were primarily interested in the impact GT has on ITB extensibility, subsequently, many subjects presented pain free and

void of functional limitations at baseline. Due to the baseline values for both pain and function ranging from .10 - .18, no real improvement were necessary.

Limitations

Limitations of this study focus on the testing procedures for both hip adduction ROM and hip abduction strength. The device used for patient positioning during the testing process was created by the researchers through clinical practice and theory of best positioning possible during the Ober's test. No gold standard exists for subject positioning during hip adduction ROM testing. Furthermore, strengthening exercises were performed isotonicly, but strength measurements were obtained isometrically in a position that targeted the gluteus medius. In addition, despite good to great intrarater reliability for the use of the HHD, potential for variability among trials for strength testing and possible learning effect over the course of the testing sessions could explain some improvements in strength results. In regards to the treatment itself, the full GT protocol of a warm up, IASTM application, stretches, strengthening exercises, and cryotherapy was not followed. This was done to determine if changes in ROM were due solely to IASTM instrumentation and not a cumulative effect of stretching exercises.

Future Research

Future research should focus on both the specifics of GT treatment as well as comparing it to other modes of treatment. Despite the Graston Technique manual recommendation of 4-8 total treatments, no research has been performed to identify the optimal number of treatments. Furthermore, a cumulative effect of both IASTM application and stretching should be evaluated in comparison to isolated interventions.

Clinical Implications

Clinically, results of this study indicate that six treatments of IASTM application are effective at increasing hip abduction strength and, thus, decreasing a predisposing factor for pathology relating to the ITB. Furthermore, although not statistically significant, an increase of 4.8° of hip adduction could be considered clinically significant in decreasing ITB tightness that has been correlated to the development of ITBFS and PFPS. Despite the proposed increase in hip adduction ROM through elongation of the TFL and other musculature, it is possible that IASTM is effective at increasing extensibility of the ITB throughout its length. The relief of soft tissue adhesions throughout the length of the ITB and relaxation of hypertonic hip abduction musculature could be more impactful than an increase in extensibility of musculature through stretching. Lastly, continued increases in ROM and strength after cessation of treatment indicate that IASTM treatment possibly has a long lasting effect that is more worthwhile than any immediate effects. These long-term effects indicate the potential that structural changes were accomplished through IASTM treatment. This improvement over time when considering the time course of the healing cascade would be consistent with a connective tissue healing time line.

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Table 1: Means and standard deviations of Graston Technique group and control group at baseline, mid tx, post tx, and 1 month follow up.

	Graston Group	Control Group
Strength (%BW)		
Baseline	9.11 ± 2.12	9.63 ± 3.78
Mid Tx	9.42 ± 2.83	10.38 ± 3.38
Post Tx	10.68 ± 3.46	10.36 ± 3.77
1 Mo Follow up	11.00 ± 3.27	10.63 ± 3.68
ROM (°)		
Baseline	12.60 ± 5.72	12.30 ± 4.93
Mid Tx	14.35 ± 4.54	13.47 ± 6.02
Post Tx	15.50 ± 5.73	14.28 ± 7.06
1 Mo Follow up	17.48 ± 7.90	13.80 ± 6.22
Pain (cm)		
Baseline	.18 ± .34	.12 ± .56
Mid Tx	.17 ± .38	.03 ± .15
Post Tx	.10 ± .21	.08 ± .28
1 Mo Follow up	.21 ± .84	.04 ± .13
Function (cm)		
Baseline	.15 ± .33	.10 ± .50
Mid Tx	.19 ± .39	.07 ± .31
Post Tx	.10 ± .19	.02 ± .08
1 Mo Follow up	.25 ± .90	.01 ± .06

LIST OF FIGURES

	PAGE
Figure 1. Hip Adduction ROM Measurement.....	21
Figure 2. Hip Abduction Strength Measurement	22
Figure 3. Pain and Function Visual Analog Scale.....	23
Figure 4. Graston Technique Instruments.....	24
Figure 5. Hip Adduction ROM Results.....	25
Figure 6. Hip Abduction Strength Results.....	26



Figure 1: Hip Adduction ROM Measurement



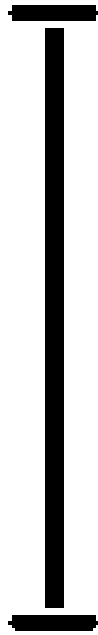
Figure 2: Hip Abduction Strength Measurement

Subject # _____ Date _____ Treatment Day _____

Pain and Function Scale

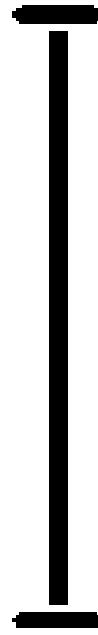
Instruction: Make a mark (-) along the line from the extremes, “No pain at all” and “No physical limitations,” which you think represents your current pain in the area of the IT Band.

PAIN AS BAD AS
IT COULD BE



NO PAIN AT ALL

NO PHYSICAL
LIMITATIONS



TOO PAINFUL
TO DO
ANYTHING

Figure 3: Pain and Function Visual Analog Scale



Figure 4: Graston Technique Instruments

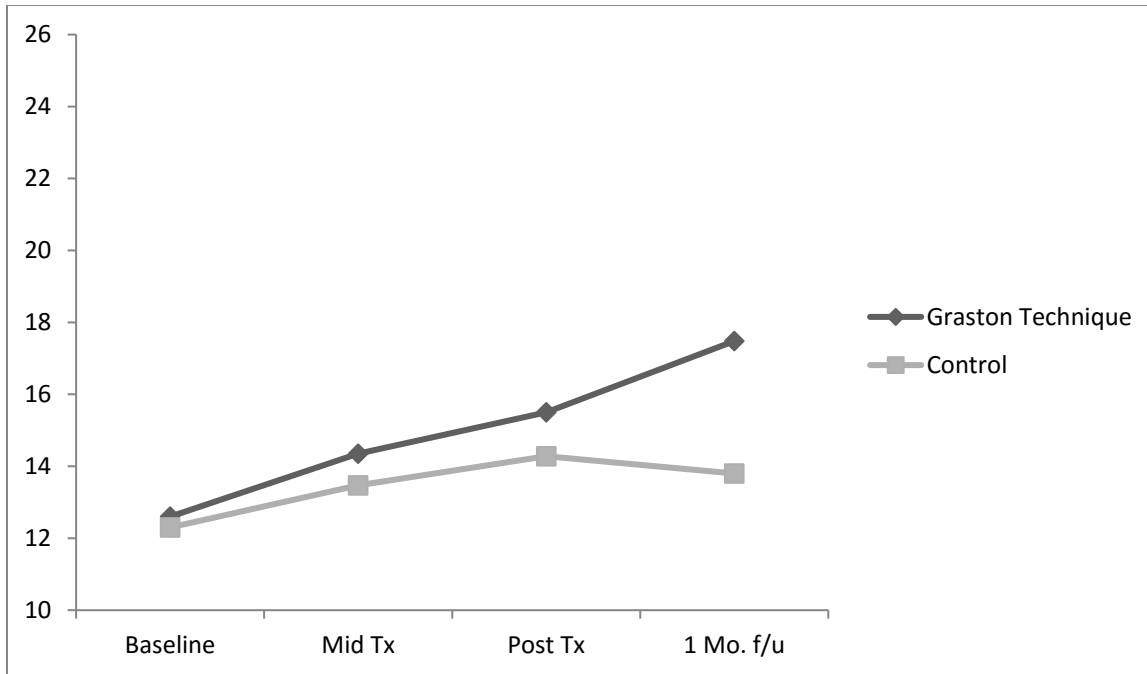


Figure 5: ROM for both groups at all 4 testing periods

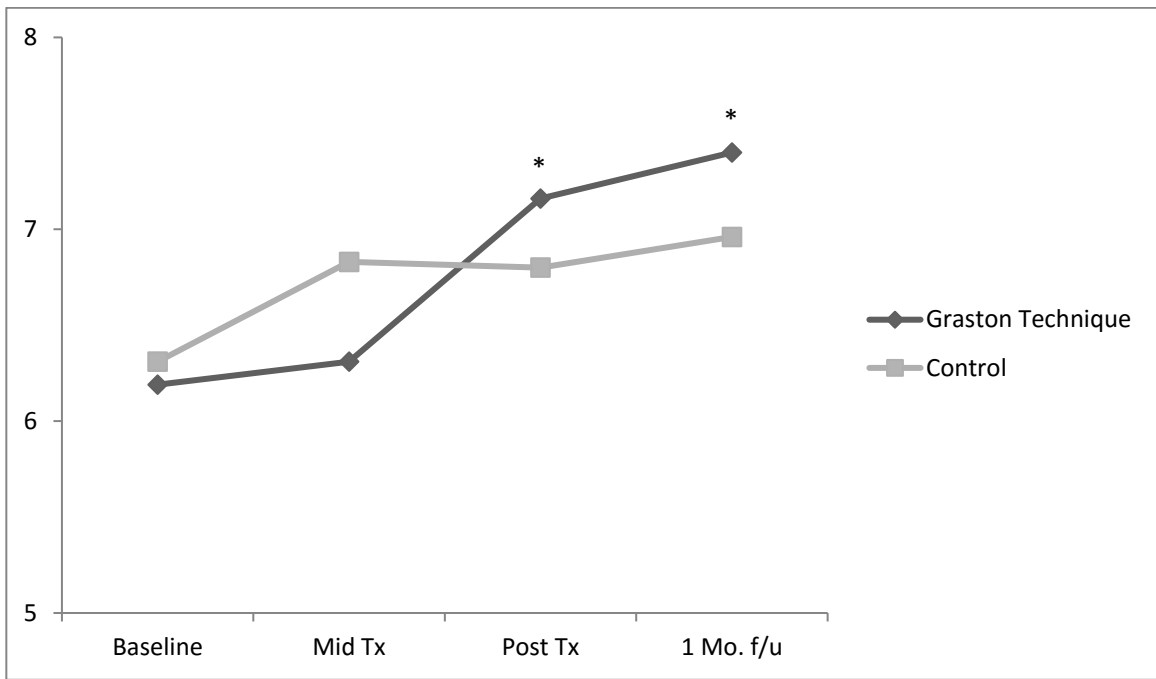


Figure 6: Strength for both groups at all 4 testing periods

APPENDICES

APPENDIX A

Operational Definitions

Assumptions

Delimitations

Limitations

Statement of Problem

Independent Variables

Dependent Variables

Research Hypothesis

Operational Definitions

Graston Technique: Each session of Graston Technique will last 8 minutes. A 5 minute cardiovascular warm-up (treadmill) will be performed at the beginning of the session. Emollient will be applied to the length of the ITB to decrease friction between the skin and instruments. Scanning, sweeping, and fanning strokes will be applied with GT-1 and GT-4 while brushing, strumming, and framing strokes will be applied with GT-3. Stretches and strengthening exercises will be given immediately following treatment. Treatment is concluded with application of an ice bag for 20 minutes.

Handheld Dynamometer: Instrument used to measure force production for isometric hip abduction. Units of measure are in Newtons.

Hip Abduction Strength: Hip abduction strength will be measured with a hand dynamometer placed just proximal to the lateral malleolus. The patient will be side-lying on non-tested leg. Patient will be instructed to actively abduct leg to 15 degrees with no pelvic rotation and instructed to isometrically contract perpendicularly to the pad of the dynamometer. Measured in Newtons.

Hip Adduction ROM: Hip adduction ROM will be measured with a digital inclinometer placed on the lateral aspect of the leg just proximal to the knee. Patient will perform a modified Ober's test to assess. Measured in degrees.

Iliotibial Band Exercises: Two low load exercises performed for 2 sets of 20 repetitions with a 30 second rest between sets. Side-lying abduction with 15 degrees of hip flexion with the leg externally rotated. Second, side-lying hip abduction to 30 degrees followed with external rotation and a return to neutral followed with lowering the leg back to the resting position.

Iliotibial Band Tightness: Subjects presenting with 26 degrees or less of hip adduction as measured by a digital inclinometer in the modified Ober's test. A value of zero is given to the leg in a horizontal plane.²⁴

Iliotibial Band Treatment Area: Treatment area for the ITB will be from Gerdy's Tubercle on anterolateral tibia to greater trochanter of the femur.

Inclinometer: Instrument used to measure range of motion. Units of measure are in degrees.

Modified Ober's Test: Subject is side-lying on non-test side with the knee and hip in 45 degrees of flexion for added support. Subject is strapped to table with a belt wrapped around at the level of the anterior superior iliac spine (ASIS), with additional support from examiner's hand placed on ASIS. Examiner's other hand is placed on the subject's lower leg and passively moves subjects leg into extension and abduction. The leg is then released and gravity provides passive motion in an adduction direction until reaching the end range or pelvic tilt is noted.

Physically Active: Engaging in aerobic exercise for at least 30 minutes at a minimum of 3 times per week.

Assumptions

The following assumptions will apply to this study:

1. Subjects will provide truthful responses to the medical history form.
2. Subjects will be compliant with investigator's instructions and be present for all treatment sessions.
3. Subjects will represent a normal physically active collegiate population.
4. Subjects will have no changes in physical exertion levels during duration of study.
5. Inclinometer measurements are acceptable in the measurement of ITB flexibility
6. The modified Ober's test provides the best position for measurement of ITB flexibility

7. Hand-held dynamometry is an acceptable measurement of hip abduction strength
8. The Graston Technique will be consistently administered for each trial

Delimitations

The following delimitations will apply to this study:

1. All subjects will be selected from a large university.
2. Graston Technique will be the only form of soft tissue mobilization utilized.
3. The modified Ober's test will be the only test performed to measure hip adduction.
4. Subjects will only be positioned side-lying for measurement of hip abduction strength.
5. Only subjects with a baseline of 26 degrees or less of hip adduction will be included.
6. All Graston Technique treatments will be performed by a Graston Technique certified provider
7. Subjects will be instructed to avoid changes in physical activity for the duration of treatment
8. All strength measurements will be in percentage of body weight times height (%BWh)
9. All hip abduction strength measurements will be measured with the same digital handheld dynamometer.
10. All hip adduction ROM measurements will be measured with the same digital inclinometer.

Limitations

1. Positioning for ROM and strength testing was based on researchers' judgement as there is no gold standard
2. Strength measurements were obtained isometrically, but exercises were performed isotonicly

3. The full GT protocol was not followed (excluded stretches)

Statement of the Problem

Soft tissue mobilization (STM) is a broad term referring to a multitude of manual and implemented techniques used to decrease soft tissue adhesions and increase tissue extensibility. Instrument Assisted Soft Tissue Mobilization (IASTM), namely Graston Technique, has been used in clinical practice since the mid 1990's. However, evidence-based research to indicate the efficacy and superiority of any form of STM over another is lacking. Therefore, the purpose of this investigation is to determine if soft tissue mobilization affects ITB extensibility, hip abduction strength, and pain and function.

Independent Variables

Four independent variables were evaluated in this study

1. Hip Adduction ROM (°)
2. Hip Abduction Strength (N)
3. Pain
4. Function

Dependent Variables

Two dependent variables were evaluated in this study

1. Group at two levels
 - a. Graston Technique
 - b. Sham Microcurrent (control)
2. Time at four levels
 - a. Baseline
 - b. Mid Treatment (after 3 treatments)

- c. Post Treatment (after 6 treatments)
- d. One month follow-up

Research Hypothesis

1. Graston Technique treatment will cause a change in the amount of hip adduction ROM
2. Graston Technique treatment will cause a change in the amount of hip abduction strength.
3. Increases in both strength and ROM will be maintained at the one month follow-up

Null Hypothesis

1. $H_0: \mu_C = \mu_{GT}$

Alternate Hypothesis

1. $H_A: \mu_C \neq \mu_{GT}$

APPENDIX B

Review of Literature

REVIEW OF LITERATURE

Muscular tightness and soft tissue restrictions can limit the range of motion available in a joint and predispose an individual to pathology.¹⁻⁵ Soft tissue restrictions are common in the iliotibial band (ITB) in physically active individuals. Tightness of the ITB commonly manifests itself in iliotibial band friction syndrome and patellofemoral pain syndrome.⁶ Soft tissue restrictions and muscular tightness are commonly treated with manual therapy techniques, such as soft tissue mobilization. This review of literature will provide (a) a review of ITB functional anatomy, fascia, ITB biomechanics, and ITB etiology; (b) examine assessment and quantification techniques of ITB extensibility and hip abduction strength; (c) explore various treatment strategies, specifically Graston Technique and self myofascial release via foam rolling.

Iliotibial Band Functional Anatomy

The iliotibial band (ITB) is a dense, collagenous band arising from the iliac crest and descending to its two attachments at the lateral femoral condyle proximally and distally at Gerdy's tubercle on the anterolateral tibia.¹ A lateral thickening of the tensor fascia lata (TFL), the iliotibial band serves as the tendon of both the TFL and gluteus maximus.⁷

Cadaveric studies revealed five distinct layers of the ITB consisting of aponeurotic, superficial, middle, deep, and capsulo-osseous.⁸ The aponeurotic layer contains fascia from the vastus lateralis, biceps femoris, and sartorius.⁸ The superficial layer contains the biceps femoris and vastus lateralis muscles along with the iliopatellar portion of the fascia lata and the lateral patellotibial ligament.⁸ The middle layer's differing fiber orientation and tight approximation to more superficial layers provide the complex with more strength.⁸ The deep layer is curved from the supracondylar area of the femur down to the tibia and fibula and provides additional thickness and strength upon blending with the superficial layer.⁸ The deepest layer of the

iliotibial band is the capsulo-osseous, primarily functioning as an anterolateral ligament of the knee.⁸

Previous literature has indicated contradictions in the presence of a bursa between the layers of the ITB.^{9,10} A cadaveric study on ten healthy knee indicated that there was a space beneath the ITB in an area consistent with positive findings of fluid collection present in an MRI of patients suffering from iliotibial band friction syndrome (ITBS).¹⁰ This bursa was theorized to be the potential source of friction in pathological patients. However, Fairclough et al⁹ conducted a similar study and found no presence of a bursa in MRI or cadaveric evaluation. The source of pain and irritation in pathological knees was contributed to compressive forces against a highly innervated layer of adipose tissue between the ITB and lateral femoral condyle.

Iliotibial Band Biomechanics

The biomechanics of the ITB both statically and dynamically provide a foundation in the understanding of underlying pathology. In a static position, the muscular pull of the tensor fascia lata and gluteus maximus maintain the band posterior to the greater trochanter.^{1,3} This position allows for the hip and knee to be maintained in extension with minimal muscle activity.¹

With locomotion, the ITB responds to motion at various phases of the gait cycle. During the swing phase, the anterior pull of the tensor fascia lata moves the ITB anterior to the greater trochanter and thus maintain the ITB in hip flexion.^{1,3} In the stance phase, as the hip extends, a posterior pull on the ITB is exhibited.¹ Distally, as the knee reaches thirty degrees of flexion, the posterior pull causes the ITB to move over the lateral femoral condyle.¹

The ITB effects patellofemoral biomechanics, potentially leading to secondary injury. Knee flexion causes the lateral knee retinaculum to be pulled posteriorly resulting in a lateral

patellar tilt.⁴ This emphasizes the importance of an equal relationship between the medial (VMO) and lateral (iliotibial band) stabilizers of the knee for proper function of the patellofemoral joint.⁴

Fascia

Fascia is a dense connective tissues with multiple functions and roles in structure and physiological processes within the body.^{7,11,12} Fascia can be divided into superficial and deep categories, both with distinguishing characteristics. Superficial fascia is considered to be a layer of soft tissue directly under the skin.⁷ Functions of the superficial fascia include conveyance of blood vessels and nerves between the skin and deeper structures as well as the promotion of movement.⁷ This movement is facilitated by the sheet-like composition of the collagenous network intermixed with elastin.

Differing from the superficial fascia, deep fascia is characterized by sheets of densely packed collagen forming a stocking around enclosed musculature.⁷ Contained in the layers of fascia are fibroblasts, myofibroblasts, and actin.^{11,12} Fibroblasts are responsible for the production of collagen, the structural unit of fascia.¹¹ Myofibroblasts develop from stimulated fibroblast cells by mechanical stress along with particular cytokines allowing for the ability to produce a contraction similar to that of smooth muscle over long durations with minimal energy expenditure.¹¹ Actin forms integral parts of the cytoskeleton, making it important in the structure and organization of fascia.¹¹

The cellular components of fascia are affected based on the position of the fascia in a stretched or relaxed position.^{7,11} The large bodied, sheet-like appearance of cells in a stretched position differ from the structure of a smaller, longer appearance when in a relaxed position.¹¹ Short bouts of stretching decreases fibroblast production and thus has the potential to limit

scarring or fibrosis after an injury has occurred.¹¹ This is particularly important in regards to the application of manual therapy in the treatment of injury.

Assessment and Quantification of Iliotibial Band Flexibility

Assessment of the iliotibial band has often been a subjective procedure, but a shift towards performing objective measurement through the use of an inclinometer has become apparent. The gold standard for the evaluation of iliotibial band flexibility is the Ober's test.¹³⁻¹⁵ The test is performed with the patient side-lying on the non-testing side with the knee flexed to 90 degrees. The examiner stabilizes the hip and passively abducts and extends the leg, letting gravity adduct their leg to the point of restriction or a pelvic rotation is observed. The test is positive if the midline of the upper leg does not abduct past horizontal.¹³⁻¹⁶ A modified version of this test has been described in which the knee is maintained in full extension.

Variations in knee position in the Ober's and modified Ober's tests have an impact on ROM measurements. Gajdosik et al¹³ performed a study correlating hip adduction ROM with knee position. The researchers concluded that 90° of knee flexion, as in the Ober's test, limits hip adduction more than the modified Ober's with the knee at 0° of flexion. Furthermore, researchers suspected that the anterolateral portion of the fascia lata and vastus lateralis were the limiting factors in the Ober's test. Along with that, due to the ITB's attachment to the lateral patellar retinaculum, knee flexion lengthens the ITB. Although there are no reports of validity of either version of the test, due to these two considerations the modified Ober's test is hypothesized to be more specific in the assessment of ITB flexibility. An ultrasonographic study¹⁷ investigated the width of the ITB in Ober's test compared to the modified version. Researchers found that the anatomical width of the ITB was significantly reduced when the leg was placed into adduction. However, stretching of the ITB as indicated by a narrowing of the ITB at greater degrees of hip

adduction ROM was only accomplished by the modified Ober's test. This indicates that the modified Ober's test might be more effective in establishing full hip adduction ROM.

Research evaluating normative values for hip adduction ROM has been performed using both the Ober's test and the modified version.^{14,15,18} The modified Ober's test was used in studies by Herrington et al¹⁸ and Reese and Bandy.¹⁵ Mean hip adduction ROM values of these studies were $16.2^{\circ} \pm 5.4^{\circ}$ and $23.2^{\circ} \pm 6.9^{\circ}$ respectively. Using the Ober's test, Ferber et al¹⁴ demonstrated a mean hip adduction ROM of $24.59^{\circ} \pm 7.27^{\circ}$. In an attempt to establish and quantify a constant hip adduction ROM measurement to classify ITB tightness, a critical criterion was established. The critical criterion was defined as the -1 standard deviation with the mean hip adduction ROM of 24.59° .¹⁴ This value was calculated to be 23.16° . Hence, in clinical application, the Ober's test should be considered positive for ITB tightness if hip adduction ROM is less than 23.16° . This critical criterion is proposed to be the objective measure that the ITB should be considered tight.

Comparison of hip adduction ROM in healthy subjects and those suffering from PFPS using the Ober's test have also been performed.^{2,16} Hudson et al² measured hip adduction ROM in both legs of twelve subjects suffering from unilateral PFPS. Authors identified hip adduction ROM of $17.3^{\circ} \pm 6.1^{\circ}$ in the unaffected leg and $14.9^{\circ} \pm 4.2^{\circ}$ in the symptomatic leg. A control group of twelve subjects had a ROM of $21.4^{\circ} \pm 4.9^{\circ}$ and $20.3^{\circ} \pm 3.8^{\circ}$ in left and right legs respectively. Similarly, Piva et al¹⁶ found a decreased hip adduction ROM in PFPS subjects. Authors identified hip adduction ROM mean measurements of $11.7^{\circ} \pm 10.2^{\circ}$ in the PFPS group and $15.0^{\circ} \pm 5.6^{\circ}$ in the control group.

Measurement of hip adduction ROM has been described extensively. Methods for assessment include standard goniometer, inclinometer, and computer assisted three-dimensional

analysis. Nussbaumer et al¹⁹ evaluated the validity of the standard goniometer in assessment of hip flexion, abduction, adduction, and internal and external rotation using an electromagnetic tracking system (ETS) as the gold standard reference. Interpretation of results identified an intraclass correlation coefficient (ICC) of 0.533 for hip adduction. Furthermore reliability of a standard goniometer for hip adduction was 0.84 compared to 0.82 of ETS. Therefore, the use of a standard goniometer is shown to be less consistent than ETS. This is due to the variability of measurement, lack of instrument specificity, and clinician interpretation.

Similar to standard goniometers, digital inclinometers are both easy to use and a cost effective alternative to three-dimensional analysis. Although there are no studies establishing the validity of inclinometer in comparison to three-dimensional analysis, the reliability has been demonstrated. Melchione and Sullivan²⁰ evaluated hip adduction with a fluid filled inclinometer. Intratester and intertester reliability was reported at 0.94 and 0.73 respectively. Furthermore, Reese and Bandy¹⁵ used an inclinometer to determine differences in reliability with Ober's test and the modified version. Intrarater reliability of the Ober's test and modified test was 0.90 and 0.91 respectively. These results favor the use of an inclinometer as opposed to a standard goniometer. Inclinometers demonstrated good to excellent reliability. The efficacy and ease of use coupled with the convenience make inclinometers a viable choice for the measurement of ROM.

Assessment and Quantification of Hip Abduction Strength

Weakness in hip abduction strength has been reported as a contributing factor in developing ITB pathology.^{21,22} Janda²¹ was the first to theorize that weakness or muscular imbalance of the hip abductors causes early firing and overactivation of the gluteus medius leading to tightness of the tensor fascia lata and iliotibial band. Fredericson et al²¹ performed a

study comparing hip abduction strength in runners suffering from ITBS to healthy runners. The healthy runners had hip abduction strength of 10.19% body weight times height (BWh) in females and 9.73% BWh for males. However, symptomatic runners had hip abduction strength of 7.82% BWh for females and 6.86% BWh for males. Furthermore, Ireland et al²² concluded that subjects presenting with PFPS demonstrated 26% less hip abduction strength than the control group. These results are in contrast to the findings of Piva et al¹⁶ who concluded that there was no difference in hip abduction strength between healthy and PFPS groups.

Assessment of hip abduction strength can be measured both subjectively and objectively in a variety of ways. Subjective measurement of strength is commonly performed in the clinical setting. Subjective measurement, also known as manual muscle tests (MMT), is performed and interpreted by the clinician. The clinician applies a counterforce to the targeted muscle group against the subject's concentric contraction. One study²³ attempted to relate subjective strength measurements performed by the clinician with objective measurements of strength by a dynamometer. A clinician was asked to determine which leg was the dominant leg when compared bilaterally. A manual muscle testing unit, consisting of a piezoelectric load cell and a charge amplifier, was used to quantify muscle strength. MMTs were applied by a trained clinician bilaterally. The clinician was able to correctly identify the stronger leg in 82% of all tests. For incorrect assessments, a difference of 6.4 – 8.8% in strength was quantified. The researchers concluded that subjective assessment of strength is accurate enough to distinguish differences in strength bilaterally.²³

However, the necessity for quantification of strength in research is paramount. Thus, objective measurement is the preferential method for assessment of strength. This is typically performed in two ways. Isokinetic dynamometry and hand-held dynamometry are the most

common methods for quantifying muscular strength. Isokinetic dynamometry has been proven to be a reliable instrument and is used as a reference standard for the comparison of other instruments measuring muscular strength. In contrast, hand-held dynamometers (HHD) are a convenient device placed between the clinician's hand and the subject's body part to be tested. The HHD has been reported as less reliable, but the ease of use and cost make it a viable and accepted replacement for isokinetic dynamometry.

A systemic review²⁴ evaluated 19 studies comparing the reliability and validity of HHD to isokinetic dynamometry. Results indicated that a HHD provides moderate to good reliability and validity when compared to isokinetic testing. Specifically to lower extremity testing, assessment of muscular strength in hip flexion, knee extension, and ankle plantarflexion and dorsiflexion was performed.²⁵ Pearson Product Moment correlations ranged from 0.92 to 0.98 with a mean of 0.94 for reliability of a HHD. Validity testing of the HHD resulted in Pearson correlations ranging from 0.60 to 0.93 with a mean of 0.78 in relation to a KinCom isokinetic dynamometer. Coefficient of variation ranged from 3.7 – 8.9% for all measurements obtained.²⁵

Specific to the measurement of hip abduction strength, good reliability (0.86–0.96) has been established.^{21,22,26} In conducting hip abduction strength assessment, the subject is typically side-lying on the non-tested leg.^{16,21,22,25-27} Subject's pelvis is stabilized by clinician's hand or belted to the table. Tested leg is then slightly extended and abducted to 30 degrees to isolate the gluteus medius. The subject is then instructed to isometrically contract against an immovable resistance applied just proximal to the lateral malleolus. A Pearson correlation coefficient of 0.86 for intrarater reliability for hip abduction strength using a HHD was demonstrated.²⁸ An interrater reliability Pearson correlation coefficient of 0.92 and ICC of 0.96 was found.²¹

ITB Pathology and Associated Treatment

ITB tightness has been described as a predisposing factor for various pathologies.^{3,4,6,29} Due to the attachment of the ITB to the patella, excessive tightness can cause a pull on the patella resulting in an abnormal alignment and tracking of the patella in the femoral groove.^{4,5} This can manifest itself as patellofemoral pain syndrome (PFPS).

Patellofemoral pain syndrome is caused by a biomechanical change in surrounding structures (tightness or muscular imbalance) resulting in a decrease in stability and function of the patella gliding during knee movement.^{4,5,30} One study evaluated the relationship between ITB tightness and patellofemoral pain in ballet dancers.⁵ Of the 14 subjects in the PFPS group, 11 exhibited IT band tightness during Ober's test while 25 of the 34 subjects in the control group presented with normal IT band flexibility. Furthermore, assessment of patellar glide in healthy subjects compared to subjects suffering from PFPS has also been performed. In one study,⁴ 17 subjects presented with a lateral tracking patella, 12 had decreased medial patellar glide and IT band tightness, 2 had decreased medial patellar glide with a negative Ober's test, and 3 had normal patellar mobility and a negative Ober's test.⁴

Conservative treatment for PFPS generally provides good results.³¹⁻³⁶ Therapeutic exercises focusing on vastus medialis oblique strengthening and stretching of the lateral knee structures are typical and effective.^{35,37,38} Furthermore, taping or bracing of the patella and foot orthoses have been shown to be effective in the relief of pain.^{31,33} Clark et al³⁴ performed a study looking at efficacy of therapeutic exercise, tape, and patient education in the treatment of PFPS. Four groups comprising of exercise and tape, exercise, tape, and patient education were evaluated at baseline and 3 months. The exercise only and tape with exercise groups both received six sessions of quadriceps strengthening and iliotibial band and hamstring stretching exercises. The tape only group and tape with exercise group received a McConnell taping at each

of the six visits. The education group received therapist advice on underlying pathomechanics, activity modification, and general treatment strategies. At 3 months, 19 of the 20 in the exercise and tape group, 20 out of 20 in the exercise group, 8 of the 19 in the tape group, and 13 of the 20 in the education group were discharged from care due to relief of pain and restoration of function. Researchers concluded that therapeutic exercise focusing on vastus medialis oblique strengthening and lateral knee structure stretching provided the most favorable results in the treatment of PFPS.

Addition of electrical stimulation in combination with a strengthening protocol has also been evaluated.^{35,36} In one study, the use of electrical stimulation on the quadriceps was compared to a control group with no electrical stimulation. Over a twelve week period, subjects in the electrical stimulation group received 20 minutes of pulsed electrical stimulation twice a day, for five days a week in combination with physical therapy. The control group performed the same physical therapy program without the electrical stimulation. No significant difference was found between groups, however an improvement of pain with the VAS of 5.3 to 1.3 in the control group and 5.6 to 1.5 was found.³⁵ Another study,³⁶ evaluated if there was any difference between multiple forms of electrical stimulation in PFPS. A biphasic pulsed electrical stimulation protocol was used in comparison to a treatment sequence specific to patellofemoral pain syndrome with alternating biphasic, bipolar, and rectangular pulses. Interpretation of results indicated no significant improvement in isometric and isokinetic strength or self-reported function in either group. Therefore, electrical stimulation has not provided good results and thus should not be used in the treatment of PFPS.^{35,36}

Similarly, iliotibial band friction syndrome (ITBS) has been attributed heavily to a tight IT band.^{27,39-41} ITBS is described as an inflammatory condition classified as an overuse injury

due to excessive friction between the IT band and lateral femoral condyle. Predisposing factors for ITBS include increase in intensity and duration of physical activity, equipment or apparel changes, and various biomechanical factors of tibial external rotation, foot pronation, and thickening of the iliotibial band.

Many treatment options for ITBS have been researched. ITBS has been treated conservatively with hip abductor strengthening and ITB stretching with generally good results.^{27,39,40,42,43} In one study,²⁷ sixteen subjects diagnosed with ITBS underwent a 6 week rehabilitation protocol consisting of three strength exercises, two ITB stretches with ultrasound, and correction of any pelvic malalignments. Results at 6 weeks indicated that the strength deficits observed at baseline were completely resolved. However, at six weeks only 4 of the 16 subjects were completely pain free. Researchers concluded that although only 25% were completely pain free, a decrease in symptoms was correlated to increased changes in strength.

Stretching of the ITB in the treatment of ITBS has also been evaluated. Falvey et al³⁹ provided quantitative assessment for the amount of strain generated in the ITB of five cadavers during the Ober test, FABER's test, and straight leg raise to 30 degrees. In all the tests, the maximal lengthening of the ITB was less than 0.5% of its total length. These results led the researchers to conclude that traditional stretching of the ITB has minimal potential for physiologic lengthening. Researchers attribute the inability to stretch the ITB to its thickness and firm attachment to the entire length of the femur.

Evaluation of the efficacy of multiple manipulation techniques has been performed. In a study⁴⁰ with thirty subjects assigned to one of three groups: chiropractic adjustive therapy to lumbar spine and pelvis, knee, foot and ankle; dry needling and ultrasound to the ITB; and a combination of the first two groups. After six treatments over the course of three weeks, all

three groups demonstrated positive outcomes with no one group being significantly different than the others. In a similar case report,⁴³ the counterstrain technique was used in the treatment of ITBFS with good results. A palpable, tender area 2 cm proximal to the tibial condyle was noticed in evaluation of a 30 year old recreational athlete. A two week counterstrain treatment protocol with 48-72 hours between treatment days was used. A home exercise program with targeted stretching and strengthening was also given. At a week follow up after the treatment protocol, the subject reported a decrease in pain and increase in function, with the ability to run without pain.

Soft tissue mobilization has not been extensively researched in the treatment of ITB extensibility, However, one study⁴² compared the effectiveness of two IASTM techniques. Graston Technique and Gua Sha were performed on subjects with ITB tightness. Results indicated no significant difference between groups, but noted an increase in hip adduction for both groups compared to the control group. Despite similar final results, the GT group experienced improvements immediately. Implications of this study indicate that soft tissue mobilization increases ITB extensibility.

Graston Technique

Introduction

Graston Instrument Assisted Soft Tissue Mobilization (GISTM) is a unique form of soft tissue mobilization that uses six stainless steel instruments to diagnose and treat soft tissue adhesions and fascial restraints.⁴⁴ GISTM is a comprehensive, five phase system. Comprising of a cardiovascular warm-up, GISTM application, targeted stretches, high repetition exercises, and cryotherapy.⁴⁴

Theory and Treatment Principles

Basic soft tissue mobilization principles and theories apply to the Graston Technique. The desired tissue response can be manipulated depending upon the stage of healing the injury is in. Effects of Graston Technique include a release and separation of fascial restrictions and collagen cross links, facilitation of reflex activity, and an increase in the cellular activity and histamine response secondary to an increase in blood flow to the target tissue.⁴⁴

The Graston Technique can be applied to multiple phases of healing and in both acute and chronic conditions.⁴⁴ If applied during the initial two days post-injury, the inflammatory stage can be re-initiated to allow for the remodeling process to begin again.⁴⁴ Progressing to the fibroblastic stage, the highly pliable nature of the collagen matrix allows for significant impact with Graston Technique to align fibers and break down cross-links caused by scarring.⁴⁴ Furthermore, a modified technique, such as a low intensity protocol, can be applied to acute conditions to push edema out of the area in a non-inflammatory method.⁴⁴ For chronic conditions, a more intensive soft tissue mobilization protocol to mobilize tissue is indicated to allow for better alignment of tissue.⁴⁴

Effect on Tissues

Mechanical loading of soft tissue via GISTM affects the extracellular matrix, namely fibroblasts, which are responsible for the production of collagen, elastin, and cytokines.⁴⁵ Manual muscle treatment increases the quantity of fibroblasts in the target tissue which serves to initiate the inflammatory process in a controlled manner and thus stimulating a healing cascade to increase local blood flow, nutrients, and fibroblasts resulting in maturation of the tissue through collagen production.⁴⁵

A study examined morphological and functional changes in rat Achilles tendon following induced tendonitis through injection of a collagenase. It was demonstrated that there was an

increase of the number of fibroblasts of the injured group as well as the group treated with Augmented Soft Tissue Mobilization (ASTM), a form of instrument assisted soft tissue mobilization.⁴⁶ Such findings indicate that ASTM induces controlled microtrauma to the treatment area. In a similar study, ASTM was used in three different intensities (light, moderate, heavy) and were compared after induced tendonitis in male rats.⁴⁷ Through light microscopy, it was concluded that the application of heavy pressure stimulated a greater amount of fibroblasts and thus contributes to the healing process more than light or moderate pressure.⁴⁷ This indicates that the pressure applied during treatment has a direct effect on tissue healing and should be considered during treatment.

Instruments

Each of the six patented GISTM instruments were designed for a specific purpose to create a lever system increasing the mechanical advantage for the clinician providing treatment.⁴⁴ The uniqueness of these instruments stems from their shape, material, treatment edge, and possible handholds and strokes for treatment. The differing concave and convex treatment edges allow instruments to conform to specific tissue contours and joint shapes permitting multiple options for treatment intensity.⁴⁴ Through clinical use, it has been said that the stainless steel material, that is unique to GISTM, is superior to the other materials used in instrument assisted soft tissue mobilization (IASTM) in detecting soft tissue dysfunctions through reverberation transmitted to the clinician's hands.⁴⁴ The treatment edges vary in single and double bevel to allow for aggressive treatment or patient comfortability. Various handholds and strokes can be applied to each instrument to accomplish a wide range of objectives by differing the amount of force applied as well as the angle, direction, and amplitude of any given stroke.⁴⁴

Treatment Strokes

Seven different strokes are utilized in the evaluation and treatment of soft tissue dysfunctions and can be grouped together by their overall purpose. Scanning strokes are characterized by a large contact area of the treatment edge with the underlying tissue and less intensity to give the clinician feedback of where soft tissue adhesions lie. Scanning strokes include sweeping and fanning.⁴⁴ Sweeping strokes are ones in which points of contact move in one direction at the same rate while the instrument in fanning strokes moves at different rates in an arched path through stabilization of one end and mobilization of the other.⁴⁴ Treatment strokes include brushing, strumming, J-stroke, swivel, and scooping.⁴⁴ Brushing is performed in a superficial manner with linear stroking motions in one direction in an attempt to mobilize superficial fascia and prepare tissue for deeper strokes. Strumming is characterized by the application of deep linear motions perpendicular to the direction of underlying fibers to mobilize a local restriction. The J-stroke can be applied either superficially or deep in a J-shaped pattern to treat adhesions at multiple depths. The swivel provides the tissue with an oscillation in treating a specific area. Scooping addresses the tissue from multiple directions to lift deep adhesions.

Typical Treatment Protocol

A typical Graston Technique treatment protocol consists of five parts in a specific order to maximize effectiveness.⁴⁴ Treatment begins with a cardiovascular warm-up typically lasting approximately ten minutes or long enough to increase core temperature of the target area to increase blood flow and tissue plasticity. Immediately following that, GISTM is applied for eight to ten minutes or less with approximately thirty seconds spent on a particular restriction to induce microtrauma to break up soft tissue adhesions. Next, a targeted stretching program is administered to increase tissue extensibility with the new range that is brought about by mobilization of the restricted tissues. Subsequently, low load, high repetition exercise protocol is

performed to facilitate the principle of specific adaptation to imposed demands (SAID) and allow for tissue alignment along tensile forces. Treatment is concluded with a form of cryotherapy to minimize the extent of inflammation and allow for plastic changes to the tissue.

Graston Technique has been used in the treatment of a variety of soft tissue pathologies ranging from acute to chronic conditions.^{45,48-57} It has been shown to be useful in the treatment of various tendinitis conditions including lateral epicondylitis,⁴⁸ plantar fasciitis,⁴⁹ Achilles tendonitis,⁴⁵ and carpal tunnel syndrome.⁵⁰ Furthermore, it has been identified to aid in the treatment of other conditions including costochondritis,⁵¹ knee arthrofibrosis,⁵² cervical radiculopathy,⁵³ non-specific thoracic pain,⁵⁴ subacute lumbar compartment syndrome,⁵⁵ trigger thumb,⁵⁶ and chronic ankle fibrosis.⁵⁷

A case study of Graston Technique increasing tissue extensibility is demonstrated by Hammer and Pfefer.⁵⁵ A 59 year old man with subacute lumbar compartment syndrome was treated with GISTM for six sessions over the course of two weeks. Upon completion of the sixth visit, the subject was completely asymptomatic and was able to achieve full passive and active trunk ROM.

Functional improvements due to Graston Technique treatment are demonstrated by a case⁵⁷ of a twenty year old male football player. History included arthroscopic surgeries to his ankle due to significant history of ankle sprains. Following five weeks of physical therapy with less than satisfactory results, Graston Technique treatments were applied twice a week for seven weeks. Concluding the treatment period, the subject had no pain with activity and significant increases in ankle ROM. An MRI following treatment revealed that scar formation had resolved and a reduction of soft tissue around the medial malleolus.

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