

EFFECT OF GRASTON TECHNIQUE ON EDEMA FOLLOWING A SPRAIN TO THE  
LATERAL ANKLE LIGAMENTS

Noah Thaman

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Carrie Docherty, PhD, ATC

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John Schrader, HSD, ATC

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Jackie Kingma, DPT, ATC, PT, PA

Date of Oral Examination

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School of Public Health  
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**TITLE: EFFECT OF GRASTON TECHNIQUE ON EDEMA FOLLOWING A SPRAIN TO THE LATERAL ANKLE LIGAMENTS.**

**STATEMENT OF THE PROBLEM:** Lateral ankle sprains are one of the most common orthopedic injuries experienced by active individuals. Deleterious effects of swelling within the ankle joint include pain and reduced functionality resulting in complications with sport and daily living activities. Treatment techniques resulting in rapid reduction of edema offer significant benefits to patients by reducing pain and increasing function. The Graston Technique, a form of soft tissue mobilization, presents a novel approach in edema reduction and requires further study.

**PURPOSE:** To evaluate the effectiveness of Graston Technique (GT) on reducing edema following an acute sprain to the ankle ligaments.

**METHODS:** 16 participants were recruited for this study. Subjects were drawn from the recreational athletic population of a large Midwestern university town and were randomly assigned to one of two groups. The GT group was treated with a single session of the Graston Technique while the control group received no treatment. Ankle girth was measured at study enrollment, 10 minutes post-treatment, and after 24 hours using the figure-of-8 method. Furthermore, subjective representations of pain and function were gathered using a Visual Analog Scale (VAS) and the Foot and Ankle Ability Measure (FAAM) respectively. A repeated measures analysis of variance was completed to assess differences between groups.

**RESULTS:** Results of the statistical analysis revealed no significant difference in reduction of ankle girth between the Graston Technique and control groups. While participants experienced decreases in girth as measured pre-test and at the 24 hour post-test, these decreases remained similar regardless of group allocation. Furthermore, assessment of subjective function and pain as measured by FAAM and VAS respectively revealed no significant difference between groups.

**CONSLUSIONS:** Current testing does not indicate that the Graston Technique is more effective than conservative management at altering ankle edema following an ankle sprain. These data indicate that a single session of GT treatment is similar in its efficacy to non-intervention at reducing swelling, decreasing pain, and increasing function.

**Outline of Studies**  
**Major: Athletic Training**

**Educational Career**  
**B.S. Palm Beach Atlantic University, 2013**

**Committee in Charge**  
**Carrie Docherty, PhD, ATC, Chair**  
**John Schrader, HSD, ATC**  
**Jackie Kingma, DPT, ATC, PT, PA**

Approved: \_\_\_\_\_  
**Carrie Docherty, PhD, ATC**

## INTRODUCTION

Lateral ankle sprains comprise the majority of injuries seen in athletics.<sup>1</sup> Following such an acute injury the body initiates the inflammatory process, a necessary and integral function of tissue healing. Although this process is essential, it does produce several undesirable effects. Mediated by chemotaxis, the inflammatory process produces cellular changes around the injured body segment that incite pain, edema development, and loss of range of motion.<sup>2</sup> It is believed the ability of an athlete to return to activity is primarily hindered by edema, since it contributes to the sensation of pain, as well as limiting joint function.<sup>2</sup> Therefore, it is ideal for healthcare clinicians to discover the most effective way to reduce acute edema. This will allow both athletes and members of the general population to progress more successfully through a rehabilitation protocol, leading to an expedited return to full weight-bearing and functional activity.

Currently, the most widely utilized approach for edema reduction is the combination of rest, ice, compression, and elevation (RICE).<sup>2</sup> Although the RICE model is the most common therapeutic approach, some evidence within the body of literature suggests that certain components of RICEs may be more effective than others.

Application of varied forms of cryotherapy following an acute injury is utilized to minimize the sensation of pain and is thought to reduce secondary hypoxic injury by slowing cellular metabolism at the site of injury.<sup>3</sup> Although analgesia is a common goal of cryotherapy, consensus within the literature does not support utilizing ice as an effective treatment for reducing edema.<sup>4</sup> Furthermore, compression studies have yielded conflicting results with the goal of affecting a decrease in ankle volume following an acute ankle sprain.<sup>4,5</sup> Elevation studies alone have documented a significant change in ankle volume, however these studies have been

few in number and present with significant limitations in standardizing a universal treatment protocol.<sup>6,7</sup>

Manual therapy techniques present an alternative recourse in the treatment of edema in the post-acute sprained ankle. Some evidence exists within the greater body of literature suggesting that forms of manual therapy may have a greater effect on the reduction of edema than the more commonly used RICEs. These forms of manual therapy include techniques such as lymphatic massage<sup>8</sup>, manual lymphatic drainage (MLD)<sup>9,10</sup>, or instrument-assisted soft tissue mobilization (IASTM). While no current study has proposed a uniform protocol for addressing edema reduction in the post-acute sprained ankle, limited research has proved their efficacy on other body segments and with various, other conditions.

IASTM using the Graston Technique (GT) instruments are used to identify, evaluate, and treat injured tissue in conjunction with a stretching and strengthening protocol.<sup>11</sup> Several studies have reported success when using IASTM with GT implements in the treatment of various chronic injuries.<sup>12-19</sup> However, fewer studies have shown positive outcomes when using any form of IASTM in the treatment of acute injuries.<sup>20-23</sup> Of these few experiments, most have utilized range of motion, tissue mechanical stability, muscle strength, or pain and functional scales as intervention outcomes.<sup>20-22</sup> Additionally, only one known IASTM study has reported edema as a dependent variable. The authors in this case report treated a strained quadriceps muscle with IASTM over a six-week period and used ultrasound imaging to observe that treating a strained quadriceps muscle with IASTM utilizing GT implements reduced injury-related edema and tissue damage.<sup>23</sup> The authors stated that utilizing IASTM in conjunction with traditional physical therapy, may have created an effective environment for healing to occur.<sup>23</sup>

Theoretically, IASTM is a viable option in the treatment of acute lateral ankle sprains due to its histological effects on the body. IASTM has been shown to reinitiate the healing process by increasing blood flow and the proliferation of fibroblasts to the injured area.<sup>24-26</sup> However, the effect of IASTM on acute injuries is still mostly unknown as most studies performed utilized chronic soft tissue injury populations. Regarding acute lateral ankle sprains specifically, increasing the amount of fibroblasts in the area of damaged soft tissue indicates greater success of repair while reassuring increased tensile strength of the tissue. The massaging effects of IASTM may improve flow of lymph and edema through the lymphatic system, thereby reducing swelling. Increasing blood flow to the ankle would also help reduce the likelihood of static structures (ligaments, joint capsule) experiencing contracture and thereby limiting joint motion. Increased blood flow, or hyperemia, has been linked to efficient, accelerated healing of damaged tissues.<sup>27</sup> Therefore, the purpose of this investigation was to measure the effectiveness of IASTM in treating the acute symptoms of a lateral ankle sprain. In particular, 1) edema and 2) patient reported pain and function was recorded prior to and after the treatment protocol.

## METHODS

### Subjects

Sixteen participants, eight (6 men, 2 women) in the IASTM group (age = 20.50 yrs.  $\pm$  2.83; height = 180.13 cm  $\pm$  9.88; weight = 84.61 kg.  $\pm$  13.03) and eight (5 men, 3 women) in the control group (age = 21.0 yrs.  $\pm$  5.71; height = 174.58 cm.  $\pm$  11.41; weight = 86.09 kg.  $\pm$  34.96) from a large Division I institution and associated local community were recruited to participate in this study. Each subject was assessed by a Certified Athletic Trainer to determine the severity of the ankle sprain. Participants were included if they sustained a grade I or grade II ankle sprain

accompanied by edema. Of the sixteen participants, eleven were assessed as a grade I sprain (5 IASTM; 6 Control) while five were assessed as a grade II sprain (3 IASTM; 2 Control).

A grade I ankle sprain presented with edema, limited range of motion, and point tenderness over the ATF. An anterior drawer test may or may not have been positive as minimal abnormal translation is seen without true disruption of the ATF. A talar tilt test was negative as there is no rupture of the CF with a grade I lateral ankle sprain.

A grade II ankle sprain was diagnosed in the presence of instability, ecchymosis, restricted range of motion and functional deficits due to edema. There was point tenderness over the ATF and the CF ligaments. There were positive anterior drawer and talar tilt tests. Both bump and squeeze tests were considered negative, ruling out fracture and syndesmosis sprains respectively.

Participants were excluded if they sustained a grade III sprain requiring surgery. The grade III lateral ankle sprain was diagnosed by the presence of excessive edema and ecchymosis, severe laxity, and a complete inability to bear weight. If all ligamentous special tests were positive, or if the clinician could not confidently differentiate between a grade II and a grade III lateral ankle sprain the participant was excluded and referred to appropriate medical care.

Additionally, participants were excluded if they also reported a history of lymphatic dysfunction, sustained a syndesmotic sprain, had a history of chronic edema, were neurologically impaired, or possessed any contraindications for IASTM treatment. The Ottawa Ankle Rules were followed to assess the comorbidity of fracture, and any participants that were considered positive were excluded and referred to an appropriate medical facility for radiography.

Before being enrolled in the study, all participants read and signed an informed consent document approved by the University's Institutional Review Board for the protection of human

participants, which approved this study. Participants in the study were randomly assigned to one of two groups. The experimental group received a single session of a non-inflammatory IASTM treatment specifically designed for edema reduction while the control group received no intervention (Figure 1).

### Instrumentation

The IASTM protocol made use of stainless steel Graston Technique implements. These patented and FDA approved implements have single bevel and double bevel treatment edges. These edges are designed to fit around soft tissue structures which are concave or convex. In this study, GT 2, GT 3, GT 4, GT 5, and GT 6 were used in the treatment of edema at the ankle joint. GT 2, is used to evaluate and treat convex shaped soft tissue with curved treatment surface. In addition, GT 2 is used to localize and treat specific soft tissue restrictions with its knob portion. GT 3 is used to localize and treat specific soft tissue restrictions. GT 4 is used to survey, evaluate, and treat most soft tissue areas. GT 5 is used to scan, evaluate and treat convex shaped tissue. Much like GT 2, GT6 is also used to evaluate and treat convex shaped soft tissue surfaces with its curved treatment surface. Its advantage over GT 2 is its ability to treat more specific surfaces due to its smaller size. Treatment strokes are adjusted through changes in direction, amplitude, rate, pressure, and angle of the instrument.

### Procedures

After sustaining a lateral ankle sprain the participant utilized rest, ice, elevation, and compression as directed by their healthcare provider. They were instructed to refrain from nonsteroidal anti-inflammatory drugs. Forty-eight hours after sustaining the qualifying ankle

sprain, the participant reported to the athletic training treatment facility to begin the treatment protocol. Before any treatment was applied, the participant completed the following pretest measures: a Visual Analog Scale (VAS) to determine subjective level of pain; the Foot and Ankle Ability Measure (FAAM), a self-reported functional outcome measure utilized to track subjective changes in perceived pain and ankle function; and an ankle girth measure to determine amount of swelling in the ankle.

The VAS is a 100 mm vertical line demarcated by the extremes of painful limits. At the very base of the line, the words “No Pain” are printed, while the words, “Worst Imaginable Pain” are printed at its apex. The participant is instructed to mark a horizontal line along the continuum of the vertical line that best corresponds to their current level of pain. The VAS has been utilized extensively within various medical disciplines and its reliability and validity are well documented.<sup>28-30</sup> Furthermore, the Minimal Detectable Change (MDC), or the smallest real difference, of the VAS appears to decrease proportionately with an increase in pain. Current evidence suggests that small increases in pain can be measured more precisely at higher levels of pain.<sup>31</sup> Of those studies which reported the MDC for the VAS, numbers ranged between 11 mm and 24 mm.<sup>31</sup>

The Minimal Clinically Important Difference (MCID) may be defined as the smallest amount of change that a patient would perceive as beneficial. Reported values for the MCID of the VAS within the literature span from 12 mm to 20 mm<sup>31,32</sup>, however one source states that the MCID may be measured to be larger at higher baseline pain levels.<sup>31</sup> This suggests that patients who present with higher initial amounts of pain must experience a larger degree of relief to report a significant change in their perception of pain on the VAS.

The FAAM was selected among other, high-quality self-assessment outcome measures due to its adequate reliability and validity;<sup>33,34</sup> its specificity to the anatomical region being studied; and its inclusion of a sports-specific subscale. The FAAM is delivered in paper format and is separated into two specific sections, a 21-item activities of daily living (ADL) subscale and an 8-item, sport-specific subscale. Each item is arranged as a 5-point Likert scale with point-orientated descriptors ranging from 4 points (no difficulty at all) to 0 points (unable to do). The two FAAM subscales are scored separately and are based out of 100 points. The total number of points recorded by the participant for each subscale are added and divided by the total number of points available (ADL – 84; Sport – 32). These numbers are then multiplied by 100 and are represented as a percentage. Results of the FAAM should always be interpreted within the perspective of the MDC and the MCID. One study records the values of the MDC as 5.7 percentage points for the ADL subscale and 12.3 percentage points for the Sport subscale while MCID values of 8 percentage points for the ADL subscale and 9 percentage points for the Sports subscale are given.<sup>35</sup>

The ankle girth measurement was completed using a figure-of-8 method (Figure 2). This was performed by seating the participant on a treatment table with his foot and ankle hanging off the end of the table. The ankle was maneuvered into a neutral position bony landmarks were identified by the investigator. The tape was initially placed midway between the tibialis anterior tendon and the lateral malleolus. It was then drawn towards the middle of the foot where it passed just distal to the navicular tuberosity. Continuing on, the tape was pulled across the arch of the foot; then up, proximal to the base of the 5<sup>th</sup> metatarsal; and across the tibialis anterior tendon just distal to the medial malleolus. To complete the measurement, the tape was pulled across the Achilles tendon, then distal to the lateral malleolus, and finally back to the point of

origin.<sup>36</sup> This measurement was completed applying neither tension to the tape nor allowing for slack or gapping to occur. Reported numbers for the MDC of the figure-of-8 technique range from 7 mm to 13 mm depending on the method used. We may then surmise that any change in ankle girth lying between these given figures can be considered significant.<sup>37</sup>

Participants in the GT treatment group received approximately 10 minutes of treatment with the implements using the protocol and the GT parameters outlined in Table 1. After treatment was completed they were instructed to remain seated upon the treatment table for a duration of 10 minutes after which a second figure-of-8 measurement, or immediate post-test, was recorded. Upon completion of the research session GT group participants were instructed to return for re-measurement 24 hours afterwards and to avoid any exertional activity.

Participants in the control group received no treatment. After completing their pretest, they were then instructed to remain seated upon the treatment table for a duration of 10 minutes after which the ankle girth measurement was taken again. Differing slightly from the GT group, control subjects were allowed to return to the research laboratory 24-48 hours later while also avoiding any exertional activity during the interval. Additionally, all participants, regardless of treatment group, were instructed not to use any self-mediated treatments (RICE, NSAIDs, etc.) before the post test.

Participants from both groups participated in the 24-hour post-test which was conducted in the same manner as the pretest. Finally, at the consummation of the study, each participant, regardless of treatment group, was given a uniform home exercise plan. This plan included standard, rehabilitative exercises focused on range of motion, neuromuscular coordination, and muscular strengthening. The clinician explained each exercise to the participant and also provided suggestions for recommended ankle bracing options.

### Statistical Analysis

To investigate changes in ankle circumference a Repeated Measures Analysis of Variance (RMANOVA) was calculated with one between factor (group at 2 levels: GT and control) and two within factors (test at 2 levels: pretest, 10-minute post-test, and 24-hour post-test; and side at 2 levels: injured and uninjured limbs). To investigate changes in pain and function, separate RMANOVA was calculated for the FAAM ADL, FAAM Sport, and the VAS with one between factor (group at 2 levels: GT and control) and one within factors (test at 2 levels: pre-test and post-test). Post hoc testing was completed on any significant differences. The alpha level was set a priori at  $p < .05$ .

### RESULTS

The means and standard deviations for all dependent variables are located in Tables 2 & 3. For the circumference dependent variable, interpretation of the results of the 2x3x2 repeated measures analysis of variance yielded a significant difference between the test times ( $F_{2,28} = 15.91, p = .01$ ), a significant difference between the injured and uninjured sides ( $F_{1,14} = 42.25, p = .01$ ), and significant time by side interaction ( $F_{2,28} = 4.84, p = .01$ ). Specifically, the injured ankle had more swelling than the uninjured side, and swelling in the injured ankle significantly decreased from pretest to post test. However, we did not identify any differences between the groups, time by group interaction, side by group interaction, nor time by side by group interaction ( $p > .05$ ) (Table 2). Therefore, swelling of all injured ankles decreased over the study period, but that reduction was not contingent on group assignment. For the FAAM ADL, FAAM Sport (Table 3), and the VAS (Figure 2) dependent variables, we identified a significant

difference between the pre-test and the post-test ( $p < .05$ ), but no significant difference between the groups ( $p > .05$ ), nor a significant time by group interaction ( $p > .05$ ). Therefore, we can conclude that pain and function improved in all participants over the study period, but it did not seem to be impacted by group assignment.

## DISCUSSION

The primary findings of this study reveal no difference between the non-inflammatory IASTM protocol group and the control group in measurements of ankle girth. Furthermore, these data also show that a significant difference did not exist between the two groups in the patient reported measurements of perceived pain and function as measured by the VAS and FAAM respectively. Statistical analysis of gathered data refuted our hypothesis that a single application of would have a significant effect on swelling, pain, and function following an acute ankle sprain.

### Edema Reduction Treatment Techniques

Few studies exist which examine the effect of IASTM on human subjects in the acute injury setting. Though widely used within the clinical setting, the effects of IASTM are still not clearly understood or explained within the available literature. Belonging to the larger family of soft tissue mobilization, the clinical study of IASTM seeks to advance our understanding of histological dynamics as influenced by the mobilization of skin, fascia, and underlying muscle.

While the current body of IASTM literature organizes its research focus around studying an inflammatory application of the treatment; to our knowledge no study yet exists that observes the effect of IASTM on influencing the aggregation of edema within a joint space following an

acute injury. In formulating our hypothesis, we examined those treatments and modalities that claim to assist in the reduction of edema following an injury, namely: elevation, compression, and other forms of soft tissue mobilization. With the basis of understanding that the accumulation of edema within and around the ankle incites pain and, theoretically, limits function we hypothesized that if we could somehow improve the rate of edema clearance, we could positively affect the perception of both pain and function.

Although no known randomized control trial has examined the relationship between IASTM and edema reduction, several studies do exist which provide varying levels of evidence on the addressment of either swelling or the perception of pain and function in the ankle utilizing common modality-mediated treatments.

While comparing elevation with intermittent compression and elevation, Tsang et al.<sup>6</sup> observed that both interventions exhibited a similar, immediate decrease in ankle volume. This difference, however, was negated after 5 minutes of gravity-dependent positioning. We may consider that gravity dependence and continued ambulation may affect the fluid gradient within the ankle. This study may be viewed in the context of a study conducted by Rucinski et al.<sup>7</sup> which studied the effect of elevation; elevation and compression; and elevation and elastic wrap application treatments on the presence of edema following an acute ankle sprain. The researchers found that the elevation group alone produced a significant decrease in ankle volume while the two remaining groups measured an increase in ankle volume. Current evidence appears to suggest that elevation may be the most critical component of limiting or reducing edema following an acute ankle sprain, however no known randomized trial has isolated elevation and compared it to non-intervention.<sup>5</sup>

Very little evidence currently exists on the best-practice for reducing swelling in the post-acute ankle. The effectiveness of RICE on reducing swelling is limited and conflicted within the literature, and high-quality recommendations or parameters for use are still lacking the benefit of solid evidence.<sup>5</sup> Additionally, the literature is sparse with evidence relating to the effects of soft tissue mobilization, however some evidence exists to suggest that forms of massage may be useful in edema reduction allowing that pressures remain below 60 mm hg.<sup>8</sup>

Some of the most promising edema-related massage research is being conducted using a form of soft tissue mobilization known as Manual Lymphatic Drainage (MLD). MLD therapy involves the utilization of slow, circular massage strokes moving from proximal to distal surfaces of the affected body segment before returning in a distal to proximal direction. The specific orientation and applied pressure of strokes is utilized with the goal of opening lymphatic vessels proximal to the site of dysfunction thereby improving lymphatic drainage. The treatment protocol theorizes that the clinician can affect a greater reduction in edema by creating an optimal environment for motility of lymphatic fluid. One study evaluated the effect of MLD on patients with chronic edema secondary to reflex sympathetic dystrophy. Study group participants were treated with a three week course of MLD coupled with a physical therapy program. After this set intervention period, participants in the study group exhibited significant, short-term reductions in upper limb volume compared to a control group whose sole intervention was the physical therapy program.<sup>9</sup>

An additional study evaluated the effect of Complete Decongestive Therapy (CDT) on patients with upper extremity lymphedema secondary to breast cancer. This CDT was performed twice a week for eight weeks and included a protocol of MLD, compression bandages, skin care, and therapeutic exercise. Although this study included no comparison group, CDT patients

experienced a mean volumetric decrease from 709 mL to 473 mL and a mean VAS score decrease from 6.9 to 1.1 mm over the treatment period.<sup>10</sup>

Although both of these studies evaluated patients with chronic or insidious pathology, some future consideration may be given to the effects of MLD-like treatment protocols on affecting the presence of edema in the acute orthopedic injury setting. The evidence from these studies suggest that future research in therapeutic massage should include lighter, superficial treatment strokes whose goal is to optimize the function of the lymphatic system.

### Clinical Implications

Based on the available literature, we may begin to explain our findings by assuming that, while some shift in edema may have been achieved directly after application of the IASTM treatment, ankle volume may have returned to near pre-treatment levels directly after resuming a gravity-dependent position. We may also theorize that the true benefit of utilizing IASTM with this treatment protocol may be similar to that of lymphatic massage.<sup>8</sup> Our protocol begins in the posterior musculature of the lower leg in the attempt to mobilize lymphatic fluid in a proximal direction. We theorize that achieving a shift in lymphatic fluid proximal to the ankle may create a vacuum within the lymphatic vessels. As the vessels are cleared, space is created for the clearance of the distal inflammatory products including proteins and other cellular debris.

In relation to perceived function, we may also be justified in calling into question the effect of swelling on subjectively reported levels of function. While evaluating this relationship between swelling and function Pugia et al.<sup>38</sup> found no significant correlation between the figure-of-8 measurement of ankle circumference and two measurements of subjectively reported function, the Ankle Osteoarthritis Scale (AOS) and the Foot and Ankle Ability Index (FAAI). In

a related study Man et al.<sup>39</sup> found no relationship between ankle volumetric measurement taken shortly following an acute ankle sprain and self-assessed ankle function as measured by the FAAI, a precursor of the Foot and Ankle Ability Measure (FAAM).

In contrast to the aforementioned studies, Hopkins et al.<sup>1</sup> found a significant decrease in both ankle dorsiflexion torque and peroneus longus EMG activity following introduction of artificial ankle effusion. The author stated that these functional deficits placed the athlete at greater risk for re-injury if cleared for a return to participation before full resolution of the ankle effusion. We may hesitantly conclude from this mixed evidence that although the presence of edema within the ankle may not create the perception of dysfunction for the injured athlete, he in actuality, may possess a higher risk for a recurrent ankle sprain or other lower limb injury.

After compiling our own data, a significant decrease in ankle circumference was seen across all subjects, however no significant decrease was noted between groups. Participants were enrolled in the study 48 hours post-injury and completed the requirements of the study approximately 72 hours after initial injury. Although we did note a significant decrease in ankle circumference from the 48 to 72 hour mark among participants, we must conclude that any reduction in ankle girth should be attributed to the body's normal healing process and not to the given intervention. In order to more fully understand our results we must take a closer look at the data to determine if, although not statistically significant, a clinically meaningful reduction in ankle girth occurred.

As the data in Table 4 indicates, although not statistically significant, there were differences in mean ankle circumferences between groups. Using the uninjured ankle as a baseline, the total mean difference between injured and uninjured ankles from enrollment to termination was 3 mm for the control group and 6 mm for the IASTM group. When consulting

the injured side alone, the control group's ankle girth decreased by 4 mm compared to the 7 mm reduction for the IASTM group. These numbers should be viewed in light of the MDC for the figure-of-8 measurement whose values have been reported between 6 mm and 12 mm. Given the sparse evidence available on IASTM we must pause to consider the implications of any differences, significant or not. According to reported values, the 8 mm difference for the IASTM group, though not statistically significant, does fall within the lower range of MDC values for the figure-of-8. We may then, with some confidence, state that although not statistically significant in comparison to the control group, the IASTM data did register a detectable change in ankle girth, as interpreted by the MDC, while the control group did not. We have already demonstrated that the IASTM protocol did not have a negative effect on our participant population, therefore the clinician must determine whether a small difference in swelling or in the perception of either pain or function could be of use within the athletic setting where small differences in these dependent variables may have some effect.

Similar to the figure-of-8 data, the IASTM group did see a greater increase in both improvement of pain and function in the FAAM ADL subscale and the VAS (Table 5). Conflicting these findings, the control group saw a nearly five point greater rise in the FAAM Sport subscale. It is not immediately clear why this should be, however it is likely that further research is needed to clarify IASTM's true effect on the perceptions of both pain and function.

### Limitations

Based upon our statistical analysis and the present research protocol we cannot, at this time, recommend IASTM as an effective means of dramatically reducing edema within the ankle following an acute sprain. Even so, we must acknowledge multiple limitations which may have

played a role in the outcome of our data. The number of participants enrolled in our study was low at  $n = 16$ . With only 8 subjects per group, our low power may have affected the outcome of our analysis. Furthermore, the quality of ankle sprains which were included in our data must be considered. Multiple participants were evaluated to have less than a 10 mm difference between injured and uninjured ankles. With so little initial edema, the environment for an effective IASTM treatment may have been absent.

### Future Research

Future research is needed to determine the true effect of IASTM on the clearance of edema within the ankle joint. Both anecdotal evidence and limited research speak to the effectiveness of IASTM in treating some chronic conditions, however the use of IASTM in the acute setting, specifically addressing swelling within and around the joint space, has yet to be determined. The authors of this study recommend that future research on this subject should include larger sample sizes, multiple sessions of IASTM, and the inclusion of other joints within the body. Furthermore, these IASTM studies should compare and contrast IASTM against other commonly used, post-acute therapeutic techniques such as massage, compression, and elevation.

### Conclusions

In conclusion, the present study did not discover a significant difference between IASTM and control groups in figure-of-8, VAS, and FAAM measurements. Although all participants improved in all three dependent variables at the completion of study, this improvement was not influenced by group allocation. Therefore, based upon the findings of these data alone, the authors cannot recommend the presented IASTM protocol as more effective

then non-intervention as a means of decreasing intra-articular edema in the ankle joint following an acute ankle sprain.

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TABLE 1. IASTM Protocol

<b>Tool</b>	<b>Grip</b>	<b>Technique</b>	<b>Patient Position</b>	<b>Picture</b>
GT4 or GT5	Two hand hold	Assess the ankle in neutral and dorsiflexion in order to vary the tension of the tissue. Sweep and Fan the Gastroc- Soleus complex Sweep the plantar fascia and heel pad with GT 4.	Prone, foot over end of the plinth	
GT 2 or GT 3	Two hand hold	Place additional pressure over the knob of GT 2 Mobilize the soft tissue lying in the groove between the Achilles tendon & the Fibula <ul style="list-style-type: none"> <li>•Laterally and medially</li> <li>•Between the tendon and the Tibia</li> </ul>	Prone foot over the end of the plinth	
GT 3	One hand hold	Mobilize the Plantar Fascial strips <ul style="list-style-type: none"> <li>•From the Metatarsal Head to the Calcaneus --Vary the fascial tension by flexing &amp; extending the great toe.</li> </ul>	Prone, foot over the end of the plinth	No picture
GT 2 or GT 6	One hand hold	Use the curve to work between the toes	Supine, foot over the end of the plinth	
GT 5	Two hand hold	Scan dorsum of foot moving proximally into anterior tibialis	Supine	
GT 4	Two hand hold	Sweep dorsum of foot to isolate pockets of edema	Supine	No picture
GT 2	Two hand hold	Work around the medial and lateral malleolus <ul style="list-style-type: none"> <li>•One hand stabilizes the tool &amp; the other distributes pressure through the knob of GT 2</li> </ul>	Supine	No picture
GT 2	One hand hold	Use the knob to mobilize tissue around talocrural and distal tibiofibular joint. Alter plantar flexion/dorsiflexion, inversion/eversion, and toe flexion/extension	Supine	

GT 2 Two  
or hand  
GT 4 hold

Sweep up the anterior musculature of the limb to shift edema proximally.

Supine



**Table 2: Ankle girth means and standard deviations for each limb of all participants**

	Control Group		IASTM Group	
	Injured Limb	Non-Injured Limb	Injured Limb	Non-Injured Limb
Pre-test (mm)	567 ± 57.6	553 ± 57.9	565 ± 56.9	544 ± 48.1
10 min. post-test (mm)	567 ± 58.3	553 ± 58.1	562 ± 57.6	543 ± 47.6
24 hrs. post-test (mm)	563 ± 57.6	552 ± 59.7	558 ± 57.3	542 ± 47.1

**Table 3: Foot and Ankle Ability Measure (FAAM) means and standard deviations for all participants expressed as percentage points**

	Control Group	IASTM Group
ADL Subscale – Pre-test	69.2 ± 12.7	60.4 ± 10.7
ADL Subscale – Post-test	78.6 ± 15.2	74.1 ± 15.1
Sport Subscale – Pre-test	36.8 ± 22.3	26.8 ± 21.7
Sport Subscale – Post test	54.4 ± 30.4	42.4 ± 16.3

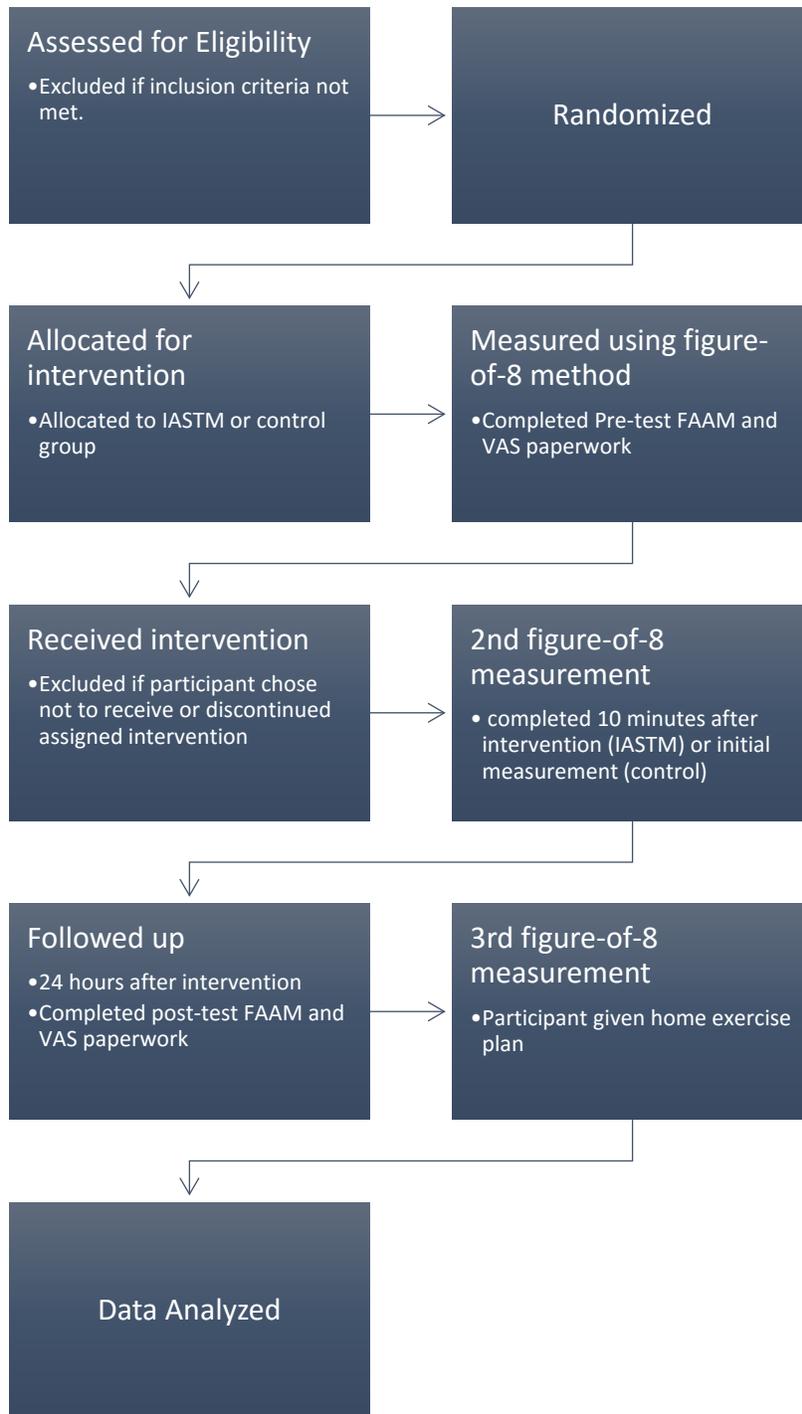
**Table 4: Mean differences between uninjured and injured ankle circumferences**

	Control Group	IASTM Group
Pre-test (mm)	14	21
10 min. post-test (mm)	14	19
24 hrs. post-test (mm)	12	16

**Table 5: Mean differences between pre-test and post-test for the FAAM and VAS scores**

	Control Group	IASTM Group
FAAM ADL Subscale (percentage points)	9.4	13.7
FAAM Sport Subscale (percentage points)	17.6	15.6
VAS (mm)	9	15

**Figure 1: Data Collection Flow Chart**



## Figure 2: Figure-of-8 Measurement

A) Medial view of landmarks for the figure of eight measurement, B) Lateral view of landmarks for the figure of eight measurement, C) Medial view of the figure of eight measurement, D) Lateral view of the figure of eight measurement.



A

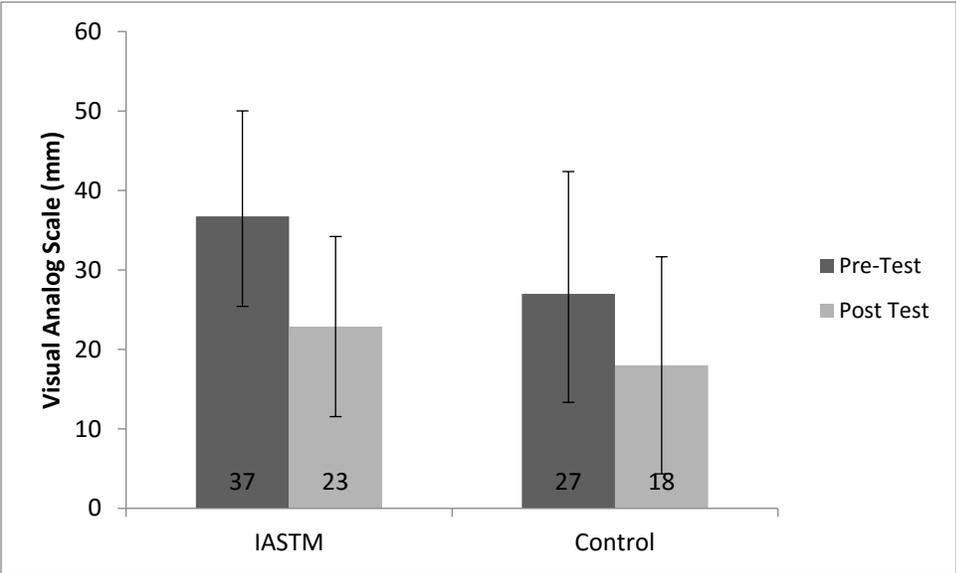
B



C

D

**Figure 3: Change in Visual Analog Scale (VAS) between groups over testing period**



## APPENDICES

APPENDIX A  
OPERATIONAL DEFINITIONS  
LIMITATIONS  
ASSUMPTIONS  
DELIMITATIONS  
STATEMENT OF THE PROBLEM  
INDEPENDENT VARIABLES  
DEPENDENT VARIABLES  
RESEARCH HYPOTHESIS  
NULL HYPOTHESIS

## OPERATIONAL DEFINITIONS

Instrument-Assisted Soft Tissue Mobilization: Manual therapy technique involving the use of stainless steel instruments in which various soft tissue structures will be stimulated in order to achieve an intended outcome of edema reduction and prevention of excessive scar tissue formation. These instruments are shaped according to their respective purpose regarding gliding over various anatomical structures such as the lateral malleolus and calcaneus as well as the specific targeted treatment outcome.

Grade I Lateral Ankle Sprain. Microscopic tearing and stretching of the anterior talofibular (ATF) ligament that presents clinically with mild edema, limited range of motion, and tenderness over the area of the ATF ligament. The anterior drawer special test will be considered positive due to anterior translation of the foot. The patient will typically present with limited functional loss and no mechanical instability of the involved ankle.

Grade II Lateral Ankle Sprain. While ankle arthrography may be the best way to differentiate between a grade I and a grade II lateral ankle sprain, in its absence a patient suffering from a grade II sprain will typically present with instability, bruising, restricted range of motion and functional deficits due to swelling of the involved ankle. Tenderness over the area of the ATF ligament and calcaneofibular (CF) ligament are due to a complete rupture of the ATF as well as partial tearing of the CF. Positive special tests will include the anterior drawer and the talar tilt, which assess the ATF and CF ligaments respectively.

Grade III Lateral Ankle Sprain. A complete rupture of the ATF and CF with potential damage to the posterior talofibular (PTF) ligament that typically presents with moderate to severe laxity, large amounts of edema, and increased discoloration and bruising of the involved ankle. Typically all special tests will be positive if deemed necessary to perform. A grade III

lateral ankle sprain also carries the possibility of a comorbid fracture. Any assessment of the ligamentous integrity of a grade III sprain also includes a survey of the surrounding skeletal structure.

Edema. The presence of fluid around the foot and ankle associated with the mechanism of injury and diagnosis of a Grade I or Grade II lateral ankle sprain as determined by the treating clinician.

Injured Participant. All participants were defined as intramural or recreational athletes from a large Midwestern university and varsity athletes from a local high school. The participants will have no previous history of chronic edema. The participants will have sustained a first or second degree ankle sprain occurring no more than 48 hours prior to pre-treatment evaluation.

Lateral Ankle Sprain. Typically associated with a mechanism of injury involving a forced inversion motion of the foot and ankle combined with plantarflexion. The lateral ligamentous complex which connects the distal fibula to the calcaneus and talus is stretched or torn creating potential loss of motion and function, as well as swelling and bruising around the lateral malleolus.

Manual therapy. Manual therapy is the mechanical stimulation of tissues utilizing rhythmically applied pressure and stretching. It involves use of hands on techniques by clinicians to evaluate, treat, and manipulate the patients' soft tissue restrictions.<sup>40</sup> It involves rubbing, kneading or stroking soft tissue to modify nutrition, restore movement, and break up adhesions.<sup>40</sup> Modes of manual therapy include: (a) massage; (b) joint and soft tissue mobilizations; (c) muscle energy; (d) active release therapy; (e) myofascial release; and (f) Graston technique (GT).

Medial Ankle Sprain. Damage to the deltoid ligamentous complex which connects the distal medial tibia to several tarsal bones in the foot. The patient will typically report a mechanism of injury of forced eversion possibly combined with external rotation of the foot. Clinically, this may present as pain, tenderness, and potential swelling and bruising around the medial malleolus.

Normal Weight Bearing Activity. The ability to ambulate without the use of any assistive devices (crutches, aircast, walking boot), and perform daily lower extremity activities without the presence of a limp.

Syndesmosis Ankle Sprain. The syndesmosis connecting the distal tibia and fibula is damaged, usually after a forceful external rotation and/or hyperdorsiflexion of the foot. The patient typically complains of anterior ankle pain just proximal to the talocrural joint, anterior and proximal to the ATF, and/or posterior and proximal to the PTF. This injury may also present clinically with swelling proximal to the lateral malleolus and discoloration around the distal tibiofibular joint.

Figure-of-eight Girth Measurement (mm) The participant will be seated on the treatment table with their foot and ankle off the end of the table. With the ankle held in a neutral position, the tape measure will initially be placed midway between the tibialis anterior tendon and lateral malleolus, continue towards the middle of the foot where it will touch just distal to the navicular tuberosity. From there, the tape measure will be pulled across the arch of the foot and up proximally to the base of the 5<sup>th</sup> metatarsal then across the tibialis anterior tendon and continue just distal to the medial malleolus. To finish, the tape measure will cross the Achilles tendon, touch just distal to the lateral malleolus and finish at the starting point.<sup>36</sup>

## **LIMITATIONS**

The following limitations apply to this study:

1. Participants have varying tolerances to pain elicited by treatment with implements.
2. The rate of edema among participants varies.
3. The rate of edema between different types of ankle sprains varies.
4. This study does not address biomechanics or mechanical pathology of the foot and ankle.

## **ASSUMPTIONS**

The following assumptions apply to this study:

1. The Certified Athletic Trainer will assess the ankle injury correctly
2. All Grade I or II ankle sprains will produce some edema.
3. The current ankle sprain is not the result of a previously unresolved ankle injury.
4. Participants are truthful on health/history questionnaire.
5. Traditional protocol is consistent with what is typically done to treat an ankle sprain.
6. Participants will perform home care procedures as instructed.
7. Participants will not participate in activity which will further exacerbate their symptoms during their period of treatment and assessment.
8. Participants will tolerate the discomfort related to the Graston Technique to a point that is deemed therapeutic
9. The Certified Athletic Trainer will apply Graston Technique treatments in a consistent and effective manner.
10. The Certified Athletic Trainer will accurately measure ankle girth during each reevaluation session.

## DELIMITATIONS

The following delimitations apply to this study:

1. Initial treatment will begin within 48 hours of the initial injury.
2. A single session of Graston technique will be applied to the experimental group while the control group will receive no intervention at all.
3. Reevaluation of ankle girth will be conducted no later than 48 hours after the initial treatment session.
4. Inclusion in this study will be limited to grade I and grade II lateral ankle sprains.
5. Participants evaluated to have sustained a grade III lateral ankle sprain will be excluded.
6. Participants evaluated to have sustained a syndesmosis sprain will be excluded.
7. Participants with a history of chronic edema will be excluded.
8. Any subject with a self-reported history of lymphatic dysfunction will be excluded.
9. Participants diagnosed with diabetes will be excluded.
10. Participants currently taking anti-coagulant medication will be excluded.
11. Participants diagnosed with anemia or other compromising circulatory dysfunction will be excluded
12. Participants suspected and subsequently diagnosed with a fracture of the foot or ankle will be excluded.
13. The following conditions will exclude participants from receiving GT treatment:
  - a. An open wound over the treatment site.
  - b. History or diagnosis of thrombophlebitis.
  - c. Patient intolerance or hypersensitivity
  - d. Presence of a hematoma.

- e. Diagnosis of osteomyelitis.
- f. Diagnosis of myositis ossificans.
- g. Diagnosis or history of hemophilia.

14. Further consideration will be given to the following conditions which may warrant exclusion.

- a. Medications including: Anticoagulants, steroids, hormone replacement therapy, and NSAIDs.
- b. History or current diagnosis of cancer.
- c. History or current diagnosis of lymphedema.
- d. History or current diagnosis of kidney dysfunction.
- e. Burn scars (9 months post-healing).
- f. Presence of an acute inflammatory condition such as synovitis.
- g. Presence of varicose veins.
- h. Presence of an inflammatory conditions secondary to infection.
- i. History or current diagnosis of rheumatoid arthritis.
- j. Pregnancy (due to inherent ligament laxity).
- k. History or current diagnosis of osteoporosis.
- l. Family history of hemophilia.
- m. Presence or history of polyneuropathies.

15. Age range will be limited to participants between 18 and 35 years of age.

16. The Foot and Ankle Ability Measure (FAAM) clinical rating scale will be used to assess the participant's subjective response to the respective treatment.

## **STATEMENT OF THE PROBLEM**

Lateral ankle sprains are one of the most common orthopedic injuries experienced within athletics and the general public. Loss of playing time among athletes and interference with normal daily activities among the general population is a result of the swelling, pain, and loss of function associated with this particular injury. Any method of treating these patients resulting in a quicker or easier return to pre-injury status should always be considered. Among the investigated acute lateral ankle sprain treatment methods, the Graston Technique is one of the few that has yet to be explored in depth. Therefore, the purpose of this investigation is to measure the effectiveness of GT in reducing acute symptoms following a lateral ankle sprain. In particular, 1) edema and 2) patient reported pain and function will be recorded prior to and after the treatment protocols.

## **INDEPENDENT VARIABLES**

Two independent variables will be evaluated for this study:

1. Group at two levels
  - a. Non-intervention, control group
  - b. GT group
2. Time at two levels
  - a. Pre-test
  - b. Post-test

## **DEPENDENT VARIABLES**

One primary dependent variable will be evaluated in this study:

1. Foot and ankle girth measurement of edema (centimeters).

Three secondary dependent variables will be evaluated in this study:

1. Patient self-reported pain measured with a Visual Analog Scale (cm).
2. Time to return to activity (number of days)
3. The Foot and Ankle Ability Measure (FAAM)

## **RESEARCH HYPOTHESIS**

1. The Graston Technique group will experience a greater reduction in swelling compared to the non-intervention control group.
2. The Graston Technique group will experience a greater reduction in pain levels compared to the non-intervention control group.
3. The Graston Technique group will experience a quicker return to activity compared to the non-intervention control group.

## **NULL HYPOTHESIS**

1. There will be no significant difference in ankle girth measurement after treatment with non-intervention following an ankle sprain.
2. There will be no significant difference in ankle girth measurement after treatment with GT treatment following an ankle sprain.
3. There will be no significant difference in pain levels with non-intervention.

4. There will be no significant difference in pain levels after treatment with GT treatment.

APPENDIX B  
REVIEW OF LITERATURE

## **INTRODUCTION**

This review of literature will focus on providing support for research investigating the Graston Technique (GT) as a treatment for reducing edema in acute ankle sprains. The review of literature will address: (a) etiology of acute ankle sprains; (b) traditional edema control protocols for acute ankle sprains; (c) types of manual therapies; (d) measuring the effectiveness of manual therapy techniques when implemented for edema reduction following injury; and (e) various patient self-reported measurements used to assess the subjective impact of pain and/or injury and function and activity.

## **ETIOLOGY OF AN ANKLE SPRAIN**

Ankle sprains are among the most frequently encountered soft tissue injuries within athletic and general populations, ranging between 10 and 15% of all time loss injuries.<sup>41</sup> An estimated total of 23,000-27,000 ankle sprains are sustained daily in the United States. Of these 85% include damage to the lateral ligaments and nearly 50% are incurred while participating in athletic activity with basketball (41.1%), football (9.3%), and soccer (7.9%) having the highest incidence of injury.<sup>1, 42, 43</sup> A majority of these injuries are sustained by individuals aged 35 years and younger.<sup>42</sup> Equivocal support exists within the literature for gender-based risk of injury to the ankle. Waterman et al. did not find that males had a lower prevalence of injury than females, however some gender-based age differences in prevalence do exist. Males between the ages of 15 and 24 were shown to have a slightly higher incidence rate of ankle injury whereas the opposite is true for females over 30.<sup>43</sup> In a slightly conflicting study, Hosea et al. found that while males and female basketball players were at equal risk for a grade II or III ankle sprain at the interscholastic and intercollegiate level, females were 25% more likely to sustain a grade I

lateral ankle sprain.<sup>44</sup> Furthermore, injury tracking performed among active duty United States military personnel revealed that members of the armed forces were five times more likely to sustain an ankle sprain than members of the general population at an injury rate of 34.95 per 1,000 person years. Additionally, of this population, females were 21% more likely to sustain a lateral ankle sprain than males.<sup>45</sup>

The most common mechanism of a lateral ankle sprain involves a combination of plantarflexion and inversion movements.<sup>42</sup> This type of stress can cause damage to one or more of the lateral ligaments which include the anterior talofibular ligament (ATF), the calcaneofibular ligament (CF), and the posterior talofibular ligament (PTF).

Damage to the anterior talofibular ligament (ATF) comprises 97% of all lateral ankle injuries.<sup>42</sup> This ligament provides a connection between the anterior, inferior border of the fibula and the neck of the talus.<sup>42</sup> Biomechanical tests show the ATF to have the lowest yield force while facing the highest load of the three lateral ligaments.<sup>42</sup>

The calcaneofibular ligament (CF) runs from the tip of the fibula to the tubercle of the calcaneus in a posterior, inferior direction deep to the peroneal tendons.<sup>42</sup> Injury to the CF does not typically occur without a sprain of the ATF, and only 20% of lateral ankle sprains involve damage to both the CF and the ATF concurrently.<sup>46</sup>

The posterior talofibular ligament (PTF) connects the digital fossa on the posterior lateral malleolus to the lateral tubercle of the talus. The CF and the PTF are at highest strain in full dorsiflexion.<sup>42</sup> Injury to the PTF is rare and occurs primarily with frank dislocation of the ankle.<sup>46</sup>

The severity of lateral ankle sprains has typically been documented using a grading scale (grade I, II, or III) although the criterion for classifying the severity of lateral ankle sprains has been a topic of debate for decades. Several authors have presented their respective definitions of

the various ankle injury grades using criteria ranging from amount of joint instability<sup>42, 47, 48</sup>, ligament pathology<sup>42, 48</sup>, effects on functional capability<sup>42, 49</sup>, the number of ligaments damaged<sup>42, 48</sup>, as well as the documented clinical symptoms.<sup>42, 47</sup> The use of one grading criterion over another has not been solely accepted in the medical field, therefore personal preference is the only determining factor in how a clinician grades an ankle sprain. In the following discussion the grading system as described by Liu<sup>42</sup> will be utilized as this criterion delineates evaluative categories to assist the clinician in determining which grade to assign to an injury.

In the aforementioned grading system, a grade one sprain presents clinically with mild edema, limited range of motion, and point tenderness over the ATF.<sup>42</sup> Grade one sprains involve microscopic tearing and stretching of the ATF with no ligamentous disruption.<sup>42</sup> With this type of sprain, there is limited functional loss and no mechanical instability. A grade two sprain is associated with a complete tear of the ATF and a partial tear of the CF.<sup>42</sup> A grade two sprain presents with instability, ecchymosis, restricted range of motion, and functional deficits due to edema.<sup>42</sup> A grade three sprain is typified by a complete rupture of the ATF and the CF with possible damage to the PTF. A third degree ankle sprain presents with moderate to severe laxity, diffuse edema, and ecchymosis.<sup>42</sup>

While injury to the lateral ligament complex is more common, between 5 and 10% of ankle injuries occur at the syndesmosis, an articulation between the distal tibia and fibula.<sup>50, 51</sup> One study reported that males at the intercollegiate level were more likely to sustain a sprain at the syndesmosis than females. Of these syndesmotoc sprains, the athletic activities with the highest incidence of injury per 100,000 exposures were: football (52.3), team handball (men's, 34.7), soccer (men's, 30.5; women's, 6.5), and basketball (men's, 24.8; women's, 6.7).<sup>52</sup>

Injuries occur at the distal syndesmosis following a forced external rotation or hyperdorsiflexion of the foot.<sup>51, 52</sup> The syndesmosis is stabilized by the anterior and posterior tibiofibular ligaments, the transverse ligament, and the interosseous membrane. The anterior tibiofibular ligament is the most frequently injured of these structures.<sup>51</sup> This type of injury presents with severe pain during passive external rotation of the foot.<sup>52</sup> Tenderness is located over the posterior tibiofibular articulation and at the anterior tibiofibular ligament proximal to the ATF.<sup>51</sup> Weight bearing is painful. Each time the foot dorsiflexes, the mortise spreads, putting increased strain on the anterior tibiofibular ligament. Syndesmosis injuries present with less edema than a lateral ankle sprain but can be more debilitating.<sup>52</sup>

In 3% of ankle injuries, damage occurs at the medial ankle.<sup>51</sup> Medial ankle sprains involve damage to the deltoid ligament which is broad and fan-shaped in composition.<sup>51</sup> Medial ankle sprains occur when the foot is everted and externally rotated. Isolated deltoid ligament trauma is rare, often occurring with a fracture of the lateral ankle and a disruption of the syndesmosis.<sup>51</sup> Weight bearing may be difficult and painful after sustaining a medial ankle sprain, and point tenderness can be palpated over the anterior aspect of the medial malleolus.

### **EDEMA CONTROL OF ACUTE ANKLE SPRAINS**

Clinicians use a system of RICES (rest, ice, compression, and elevation) for conservative management of soft tissue injuries. After an acute ankle sprain occurs, treatment and rehabilitation should be focused on management of edema as uncontrolled effusion can result in the obstruction and collapse of lymphatic vessels in the ankle joint.<sup>2, 49</sup> Early management with RICES and non-steroidal anti-inflammatory drugs (NSAIDs) can limit residual functional deficits

such as loss of joint stability, decreased strength in dynamic stabilizing muscles, and loss of proprioception.<sup>2</sup>

Ice is the most commonly used modality for treating musculoskeletal injuries, and its use is effective in the management of acute and chronic conditions.<sup>53</sup> Cryotherapy is utilized immediately following an acute ankle sprain, as well as throughout the rehabilitation process. Immediate use is indicated to reduce cellular metabolism and to minimize secondary hypoxic injury and associated tissue damage.<sup>54</sup> Vasoconstriction, analgesia, reduced inflammation, decreased tissue metabolism, and decreased nerve conduction velocity are among the effects of cryotherapy.<sup>54</sup>

Cryotherapy is effective in the treatment of musculoskeletal injuries, however its effectiveness can be affected by the duration and method of application as well as the amount of underlying subcutaneous fat.<sup>54</sup> Cryotherapy can be applied in the form of an ice bag, cold pack, slush bucket, cold spray, or cold whirlpool immersion.<sup>55</sup> Research indicates that significant tissue cooling occurs following a 20 minute application of cryotherapy, and current, accepted protocol states that ice should be applied for 20 minutes every 2 to 3 hours for the first 48 hours following acute injury.<sup>53-55</sup> In order to achieve maximum therapeutic effects, tissue temperature must be reduced 10 to 15 degrees.<sup>54</sup>

According to a clinical study, a layering of a moistened ACE wrap, ice bag, and additional ACE wrap was proven to be the most effective method of tissue cooling when compared side by side with other forms of cryotherapy.<sup>55</sup> Additionally, using an elastic wrap to secure an ice bag has been proven to be more effective at decreasing intramuscular tissue temperature compared to Flex-i-Wrap or no wrap.<sup>56</sup>

Compression is another therapeutic element utilized to control edema following an acute ankle sprain. Theoretically, compression reduces edema by affecting the pressure gradient in the damaged soft tissue thereby arresting hemorrhage and reducing subsequent swelling.<sup>5, 6, 57, 58</sup> In addition, compression is also thought to affect the healing process by reducing the space available for the collection of edema; promoting the removal of myocellular proteins and inflammatory mediators;<sup>58</sup> and alleviating the severity of DOMS-related pain following eccentric exercise.<sup>59</sup> Intermittent compression works through sequentially inflating multiple compartments facilitating lymphatic flow and reducing edema through a massaging, pumping action.<sup>6</sup> Compression treatments last 20 to 30 minutes with pressures between 30 and 60 mm Hg.<sup>6</sup>

Elastic bandages are another form of compression which may be used to restrict range of motion and limit edema. When used for edema control following an acute ankle sprain, the elastic bandaging begins at the toes and extends to the mid gastrocnemius.<sup>2, 57</sup> A U-shaped piece of felt may also be placed around the lateral malleolus, achieving focal compression and increasing hydrostatic compression within the affected tissue.<sup>57</sup> Application of a U-shaped pad appears to facilitate a recovery of ankle function earlier in individuals compared alongside those treated with a more uniform mode of support.<sup>2</sup> While used in combination with the other key components of RICEs, compression appears to aid in the acute care of musculoskeletal injuries, however, only limited research suggests that ice and compression is more effective than compression alone. Additional research is needed to isolate the individual contribution of compression in acute injury care.<sup>60</sup>

Elevation has been studied, and found to be the most important component of rehabilitation following an acute ankle sprain.<sup>6</sup> Elevation theory states that raising the affected limb above the level of the heart lowers pressure in local blood vessels, assisting in limiting

injury-related bleeding. Additionally, elevation is thought to have some effect on decreasing the formation of edema by assisting in the drainage of exudate and inflammatory by-product via the lymphatic system.<sup>5</sup> Elevation of the injured extremity is recommended to be six to ten inches above the athlete's heart and treatment is suggested to last 30 minutes in duration.<sup>6</sup> While elevation is an integral component of the RICE approach to treatment, there is some conflict within the literature regarding the efficacy of its application. One study evaluating elevation both in isolation and in combination with intermittent compression produced a marked decrease in post-acute ankle volume, however this reduction of volume was negated in fewer than 5 minutes after the affected limb was returned to a gravity dependent position. This study highlights the undesirable effects of gravity dependence on the post-acute ankle, and the transient effectiveness of elevation on ankle volume. These results shed some doubt on the efficacy of the elevation component, however still unknown is the role of elevation immediately following ankle injury.<sup>6</sup> Further research is needed to provide consensus on the subject.

In addition to treatment with RICE principles; therapeutic modalities and NSAIDs can be used to promote a rapid return to full function and activity. A number of studies have reported that modalities do not accelerate the healing process, but instead they control the negative effects of inflammation and provide the best environment for healing.<sup>38</sup> High voltage, pulsed stimulation is used for the reduction of pain and edema in the acute phase of traumatic injury.<sup>38</sup> The efficacy of NSAIDs has been studied in the treatment of acute soft tissue injury and were found to be more effective than placebo in terms of return to function, tenderness, edema, and pain.<sup>61</sup>

## TYPES OF MANUAL THERAPIES

While a variety of manual therapy techniques exist, only two will be reviewed in the following paragraphs: soft tissue mobilization and the Graston Technique (GT). These techniques are widely used in clinical settings, but few studies presently exist which report their efficacy.

### Soft Tissue Mobilization

Soft tissue mobilization is the physical action of systematic manipulation of soft tissues for restorative and rehabilitative purposes.<sup>40</sup> There are multiple strokes which stimulate relaxation of muscles and vasodilatation of blood vessels. Physiologic effects of soft tissue mobilization include decreased pain via the release of endogenous opioids; increased blood and lymph flow; increased tissue extensibility; pain modulation; and reduced edema.<sup>62</sup>

Lymphatic massage is a method of soft tissue mobilization which may be used in all stages of healing but may be modified specifically for the acute injury. Selection of lymphatic massage is made with the goal of increasing lymphatic flow by increasing the efficiency and frequency of lymphatic vessel contraction.<sup>8</sup> Administration of this technique involves longitudinal stimulation of lymphatic vessels by lightly stretching the subcutaneous tissue against its underlying fascia to its elastic capacity. Lymphatic vessels are anchored to underlying tissue by elastic filaments and stimulation of these fibers creates a stretch response thereby facilitating the movement of lymph in the direction of the heart.<sup>8</sup> All strokes should be pain free and in the direction of regional lymph nodes, using the ideological pressure of the weight of a quarter.<sup>8, 62</sup> In the acute condition, lymphatic massage should begin proximal to the location of the injury, creating a sort of vacuum for proteins and other cellular debris to move from injured, interstitial spaces and into the lymphatic vessels. Protein lingering at the site of the injury

perpetuates edema by pulling fluid back into the interstitial spaces, therefore it is necessary to create space proximal to the injured tissue for inflammatory by-products to move.<sup>8</sup>

Other common massage strokes typically associated with injury care are effleurage and petrissage. Effleurage is a type of massage that incorporates light superficial strokes moving from distal to proximal surfaces. Petrissage is a compressive stroke using intermittent manipulation and kneading of the soft tissue<sup>63</sup> and has been shown to positively affect joint flexibility in the ankle.<sup>64</sup>

Deep transverse friction massage (DTFM), is a technique used to alleviate the effects of pain and inflammation in tissues.<sup>65</sup> DTFM has been shown to be effective in acute healing and attempts to reduce fibrotic adhesions and mobilize scar tissue in chronic injuries.<sup>65</sup> Its theorized effect on acute tissue healing lies in its ability to break cross bridges and prevent abnormal scarring.<sup>65</sup>

#### Graston Technique (GT)

GT is a variation of soft tissue mobilization which uses stainless steel instruments to treat musculoskeletal conditions by providing contact mobilization force. The instruments are solid, handheld devices with angled edges which are guided in a stroking motion along the skin.<sup>12</sup> Each of the instruments can be held in a variety of positions depending on the body part being treated and goal of the treatment. The instruments are used to mobilize the tissue in longitudinal strokes parallel to fiber alignment of underlying soft tissue.<sup>12</sup> Screening strokes are utilized at the initiation of treatment and are best described as smooth and flowing. As the instruments move over an area with a fibrotic lesion a change in texture is palpable through the instruments.<sup>12</sup> Once a lesion is located, strokes are shortened and pressure is increased to mobilize the lesion.<sup>12</sup>

Two studies have been done on the Achilles tendons of Sprague-Dawley rats. The first study was done to determine the effects of ISTM on the morphological and functional characteristics of enzyme injured rat Achilles tendons.<sup>11</sup> Changes were assessed by gait analysis, light and electron microscopy and immunostaining.<sup>11</sup> Results of light microscopy indicated increased fibroblast proliferation in the fibroblast plus ISTM group, which may indicate that ISTM promotes healing through increased fibroblast recruitment.<sup>11</sup>

The second study by Gelshen et al.<sup>66</sup>, assessed morphological changes in rat Achilles tendons following enzyme-induced injury with subsequent pressure variations. The rats were divided into 5 groups. The group that exhibited a significant difference in the number of fibroblasts was “tendonitis plus extreme ISTM.” This may indicate that the application of more pressure is more beneficial than light or moderate pressure.<sup>66</sup>

In a case study presented by Melham et al.<sup>12</sup>, a division III college football player with chronic soft tissue fibrosis in the ankle joint experienced decreased pain and gains in range of motion and function following treatment with ISTM.<sup>12</sup> In an additional study of ISTM use for patellar tendonitis, researchers found an 82% success rate with ISTM when compared with a 39% success rate with phonophoresis and cross friction massage.<sup>66</sup> In a study by Sevier et al.<sup>14</sup>, the authors conclude that ISTM appears to reduce impairment associated with limited ROM secondary to soft tissue restrictions when compared with other treatment methods of lateral epicondylitis.

A moderate body of evidence exists for the benefit of using ISTM in the treatment of acute and chronic orthopedic conditions, but more research is warranted to create a consensus within the literature on its implementation. Likewise, the Graston Technique (GT), a form of ISTM, has developed some regard within the clinical setting as a beneficial and useful

intervention. At the time of this writing, very little research has been done on the effectiveness of implementing the Graston Technique in the treatment of acute injuries. In addition, there is a lack of evidence regarding ISTM and its contribution to edema control. Current studies have focused on changes in tissue extensibility and healing rates when introducing ISTM in the treatment protocol of predominately chronic conditions. Addressing the acute injury, GT has been shown to be useful in accelerating ligament healing in rats by positively influencing collagen formation and organization.<sup>20</sup> Data showed that medial collateral ligament tears, treated with GT three times a week for four weeks, were stronger, stiffer, and could absorb more energy before failure when compared to the MCL tears not treated with GT. Other research has shown that patients with patellar tendonopathy<sup>17</sup>, Achilles tendonitis<sup>18</sup>, plantar fasciitis<sup>19</sup>, and chronic ankle instability<sup>16</sup> can benefit from GT. What research that exists records that soft tissue load deformation from GT resulted in the reduction of pain and the normalization of positive functional tests.<sup>15-19</sup>

### **MEASUREMENT OF EDEMA**

Traditionally edema within the ankle has been measured using either water displacement volumetry or the figure-of-eight tape measurement. It is not within the scope of this study to assess ankle volume therefore edema will be measured by assessing ankle girth using the figure-of-eight measurement.

To assess edema using the figure of eight circumferential method, the ankle is placed in subtalar neutral.<sup>67</sup> A tape measure is brought from midway between the tibialis anterior tendon and the lateral malleolus, across distally to the navicular tuberosity, across the arch proximal to the base of the 5<sup>th</sup> metatarsal, around the ankle joint and back to the beginning mark.<sup>36</sup> This

method has been used repeatedly within the literature and is regarded as both valid and reliable.<sup>38, 67, 68</sup>

## **PATIENT SELF-REPORTED ASSESSMENTS FOR THE FOOT**

While swelling and ligamentous integrity can be measured in a fairly objective manner, pain and injury-related disability are often much more difficult to evaluate and quantify. Humans experience pain and functional loss in an individual manner, and the subjectivity of sensation often creates difficulty for the clinician to assess initial injury severity and the progress of its healing process. In an attempt to establish a reliable method to evaluate pain and disability, many patient self-reported assessments have been created to provide greater context for how the patient is experiencing pain and difficulty in movement and function.

The Foot Functional Index (FFI) was originally developed in 1991 to assess the impact of foot pathology on pain, disability and activity limitations in patients with rheumatoid arthritis. The FFI has been shown to have a high correlation with dysfunction in subjects with advanced stage RA.<sup>69</sup> The FFI has also been validated within the literature in populations with RA however, it was not initially developed as a tool strictly for measuring foot dysfunction in patients with RA. In 2006, the FFI was revised into the Foot Function Index Revised, or FFI-R, in response to criticisms from clinicians. Items added to the FFI-R included measures for psychosocial activities and foot-related quality of life.<sup>70</sup> The FFI-R is divided into two sections, the FFI-R long form and the FFI-R short form. The long form contains 5 subscales (pain, stiffness, difficulty, activity limitation, and social issues) with a total of 68 items, whereas the short form is limited to 34 items falling into the same 5 subscales as the long form. Questions within the FFI-R are graded on scale of 1 to 4 with answers ranging from "none of the time" to

"all of the time". The questions are written in a user friendly manner with language set at an 8th grade reading level.<sup>70</sup> Each section is scored individually out of 100 percentage points while the total score is obtained out of 100 percentage points for the 34 items of the FFI-R S and the 68 items of the FFI-R L. While the FFI was originally formulated to measure dysfunction in patients with RA, the test has been proven to be both reliable and valid for multiple ankle and foot dysfunctions.<sup>34</sup>

The Foot and Ankle Ability Measure (FAAM) is an updated version of the Foot and Ankle Disability Index (FADI). The two measures are identical except for five questions on the FADI that were eliminated when it was revised into the FAAM due to factor analysis and response theory results.<sup>34</sup> Of the items that were removed, four related to pain and the fifth addressed quality of sleep.

The FAAM is a region specific instrument for the ankle comprised of a 21 question activities of daily living subscale and an 8 question sport-specific subscale. Patients are prompted to answer each question by checking boxes ranging in severity from "no difficulty" to "unable to do". A Likert scale is used to score all items and higher numbers are associated with higher levels of function. Additionally, at the end of each subscale the patient is prompted to evaluate their associated level of function as a percentage out of 100 total points, giving the clinician an additional indicator of level of perceived function. The FAAM has been evaluated to be a reliable and valid instrument in measuring subjective function in patients with diabetes<sup>71</sup> and a wide variety of lower limb orthopedic injuries.<sup>33-35, 72</sup>

Another popular group of clinical rating scales for the lower limb are those developed by the American Orthopedic Foot and Ankle Society. The AOFAS measures subdivide the foot into four separate anatomical categories: ankle-hindfoot, midfoot, hallux, and lesser toes. Of particular note to this discussion is the rating scale developed for the ankle and hindfoot as this measure is most applicable to the lateral ankle sprain. The rating scale is broken down into three main categories: pain, function, and alignment with a combined 29 total items. Pain is graded as one of four options ranging from no pain (40 points) to severe/ever present pain (0 points). Function is assessed using a variety of functional and recreational tasks and assigning point values based on their specific limitations or the lack thereof. Alignment is measured by assessing the plantigrade foot and any associated malalignments.

Although widely used, the AOFAS deviates slightly from the norm as it is not specifically patient self-reported. The AOFAS relies on a trained clinician to make an assessment of gait, ankle stability, and anatomical alignment. While these are necessary pieces of information to gather in order to gain the complete picture of the ankle, their measurement requires a certain level of skill from the clinician. An inherent amount of subjectivity is introduced here as a measurement of these factors may vary from clinician to clinician. The time and personnel constrains associated with using this rating scale may also present a drawback to its usage depending on the nature of the study or clinical application. This is not to say that the AOFAS should be written off when selecting a clinical rating scale. It has been proven to contain a moderately strong correlation of validity when compared alongside other popular self-reported outcome measures including the FAAM and the FFI.<sup>72</sup>

The final clinical rating scale to be considered is the Lower Extremity Functional Scale (LEFS). The LEFS is composed of 20 total questions scored between 0 (extremely difficult) and

4 (no difficulty). Its items cover general lower body activities ranging from functional to recreational. It is not specific to the ankle but can be used as an indicator for how ankle pain is affecting movements along the kinetic chain. The LEFS has been clinically tested to be reliable and valid within both physical therapy<sup>73</sup> and sports medicine settings. It has been used as a reliable tool in patients recovering from ankle fractures<sup>74</sup> and in athletes recovering from traumatic ankle sprains.<sup>34</sup> It is shown to have a higher specificity to lower extremity dysfunction than the SF-36, a measure of established validity which has been used to assess hip, knee, and ankle impairment.<sup>73</sup>

Selection of a patient outcome measure should be made with consideration to the specificity, reliability, and validity to the body segment and associated pathology. In the absence of a gold standard for measuring the present injury, it is recommended to use the generic or region-specific instrument with the greatest amount of evidence supporting its validity within the selected patient population. For the sake of this present study, the FAAM has been selected as it combines both functional and exertional elements in its evaluation of patient reported levels of pain and dysfunction.

## **SUMMARY**

Acute ankle sprains are one of the most common soft tissue injuries. Lateral ankle sprains occur most often with an inversion and plantarflexion mechanism and are graded in three degrees. Conservative treatment including rest, ice, compression and elevation is most often used to treat an acute ankle sprain. In addition to these treatments, there are complementary therapies such as manual therapies which can facilitate the rehabilitation process. Graston Technique is a manual therapy which utilizes stainless steel instruments to mobilize underlying

tissues. GT has been studied and been found to be clinically effective in the treatment of chronic conditions. GT might also be used to treat acute conditions such as an acute ankle sprain. This study will examine the effectiveness of GT on edema following an acute ankle sprain through the use of figure-of-8 measurements.

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APPENDIX C  
DATA PROCEDURES FORM

## Procedures List

1. Set up GT treatment area
  - a. Towels for draping
  - b. Emollient
  - c. Latex gloves
  - d. Implements
    - i. GT 2, GT3, GT 4, GT5
  - e. Cavicide
2. Have pencil and clipboard with
  - a. data collection form
  - b. history questionnaire
  - c. Visual Analog Scale (VAS)
  - d. Foot and Ankle Ability Measure (FAAM)
3. Set up the patient for the figure eight girth measurement on the treatment table
  - a. “You will be sitting with both feet hanging off the end of the table with half of your calf still on the table. You will place your injured leg over a bolster. Your injured ankle will be maintained in a neutral position while I perform the measurement.”
4. Perform figure eight girth measurement on injured ankle
  - a. Tape measure begins midway between the tibialis anterior tendon and lateral malleolus and is drawn medially across the instep and placed just distal to the navicular tuberosity. The tape measure is then pulled across the arch and up just proximal to the base of the 5<sup>th</sup> metatarsal and continued across the tibialis anterior tendon around the ankle joint just distal to the distal tip of the medial malleolus, across the Achilles tendon, going just distal to the distal tip of the lateral malleolus and ending at the beginning point. Girth will be measured to the nearest cm.

5. Perform figure eight girth measurement on uninjured ankle
6. Instruct participant to rate pain on visual analog scale prior to treatment.
7. Instruct participant to complete the Foot and Ankle Ability Measure
8. Perform GT treatment
9. Participants will be instructed on home care procedures.
  - a. No participation in sport activity. The participant must notify the researcher if physical activity is performed during 24 hour the testing interval.
  - b. Activity during this period should limit weight bearing.
  - c. The participant should not administer any self-mediated treatments (RICEs, NSAIDs, etc)
10. Participant, regardless of group assignment, will be instructed to return in 24 hours for posttest evaluation
11. Take towel and cavicide and clean implements.
12. Return participant's data collection form to file.

APPENDIX D  
DATA COLLECTION FORMS

Subject # \_\_\_\_\_

Health History Questionnaire

1. Do you have any current medical conditions? Yes No  
If yes, please explain \_\_\_\_\_  
\_\_\_\_\_
2. Are you currently taking any anti-coagulants or other medication? Yes No  
If yes, please list which medications \_\_\_\_\_  
\_\_\_\_\_
3. Have you had any surgeries to your foot/ankle? Yes No  
If yes, please list which surgeries and when \_\_\_\_\_  
\_\_\_\_\_
4. Do you currently have any orthopedic conditions? Yes No  
If yes, please explain \_\_\_\_\_  
\_\_\_\_\_
5. Are you currently suffering from any illnesses? (cold, flu, ear infection, sinus infections, etc.)  
Yes No  
If yes, please list which illnesses \_\_\_\_\_  
\_\_\_\_\_
6. Are you currently seeking treatment for any other leg/foot/ankle condition or injury?  
Yes No  
If yes, please explain \_\_\_\_\_  
\_\_\_\_\_
7. Have you ever injured your foot/ankle prior to this injury? Yes No  
If yes, please explain \_\_\_\_\_  
\_\_\_\_\_
8. Do you currently wear any protective/supportive equipment for your leg/foot/ankle?  
Yes No  
If yes, please explain \_\_\_\_\_  
\_\_\_\_\_
9. Have you ever received Graston Technique treatment before? Yes No  
If yes, please explain \_\_\_\_\_  
\_\_\_\_\_
10. Do you have any allergies? Yes No  
If yes, please explain \_\_\_\_\_  
\_\_\_\_\_

METHODS OF TREATING AN ANKLE SPRAIN

Subject # \_\_\_\_\_

AGE \_\_\_\_\_yrs

HEIGHT \_\_\_\_\_cm

WEIGHT \_\_\_\_\_kg

INJURY DATE \_\_\_\_\_

INJURED LIMB **R L**

GRADE **I II**

GROUP **MODIFIED GT CONTROL**

Measurements	Pretest	Posttest	Comments
Figure-of-8 (Injured)			
Figure-of-8 (Non-injured)			
VAS			
FAAM			

Additional comments:

**Foot and Ankle Ability Measure (FAAM)**  
**Activities of Daily Living Subscale**

Please answer **every question** with **one response** that most closely describes your condition within the past week.

If the activity in question is limited by something other than your foot or ankle mark “Not Applicable” (N/A).

	No Difficulty	Slight Difficulty	Moderate Difficulty	Extreme Difficulty	Unable to do	N/A
Standing	<input type="checkbox"/>					
Walking on even Ground	<input type="checkbox"/>					
Walking on even ground without shoes	<input type="checkbox"/>					
Walking up hills	<input type="checkbox"/>					
Walking down hills	<input type="checkbox"/>					
Going up stairs	<input type="checkbox"/>					
Going down stairs	<input type="checkbox"/>					
Walking on uneven ground	<input type="checkbox"/>					
Stepping up and down curbs	<input type="checkbox"/>					
Squatting	<input type="checkbox"/>					
Coming up on your toes	<input type="checkbox"/>					
Walking initially	<input type="checkbox"/>					
Walking 5 minutes or less	<input type="checkbox"/>					
Walking approximately 10 minutes	<input type="checkbox"/>					
Walking 15 minutes or greater	<input type="checkbox"/>					

**Foot and Ankle Ability Measure (FAAM)**  
**Activities of Daily Living Subscale**  
**Page 2**

Because of your foot and ankle how much difficulty do you have with:

	No Difficulty at all	Slight Difficulty	Moderate Difficulty	Extreme Difficulty	Unable to do	N/A
Home responsibilities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Activities of daily living	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Personal care	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light to moderate work (standing, walking)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heavy work (push/pulling, climbing, carrying)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recreational activities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How would you rate your current level of function during you usual activities of daily living from 0 to 100 with 100 being your level of function prior to your foot or ankle problem and 0 being the inability to perform any of your usual daily activities.

\_\_\_ \_\_\_ \_\_\_ . 0 %

Martin, R; Irrgang, J; Burdett, R; Conti, S; VanSwearingen, J: Evidence of Validity for the Foot and Ankle Ability Measure. Foot and Ankle International. Vol.26, No.11: 968-983, 2005.

## Foot and Ankle Ability Measure (FAAM) Sports Subscale

Because of your foot and ankle how much difficulty do you have with:

	No Difficulty at all	Slight Difficulty	Moderate Difficulty	Extreme Difficulty	Unable to do	N/A
Running	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Jumping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Landing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Starting and stopping quickly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cutting/lateral Movements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ability to perform Activity with your Normal technique	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ability to participate In your desired sport As long as you like	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How would you rate your current level of function during your sports related activities from 0 to 100 with 100 being your level of function prior to your foot or ankle problem and 0 being the inability to perform any of your usual daily activities?

\_\_\_ . 0%

Overall, how would you rate your current level of function?

Normal     Nearly Normal     Abnormal     Severely Abnormal

Martin, R; Irrgang, J; Burdett, R; Conti, S; VanSwearingen, J: Evidence of Validity for the Foot and Ankle Ability Measure. Foot and Ankle International. Vol.26, No.11: 968-983, 2005.

Visual Analog Scale (VAS)

**VISUAL ANALOG SCALE**

**The Worst Imaginable Pain**

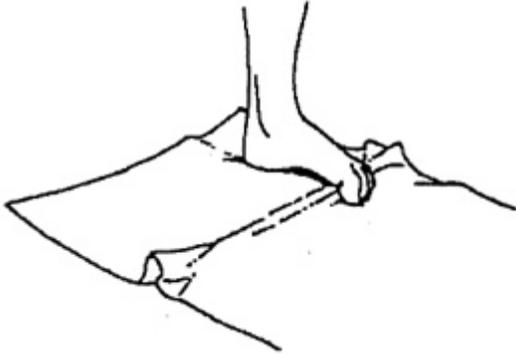


**No pain**

Ankle Sprain Follow Up Care Sheet

Towel Toe Curls

- While seated, place foot on towel curl toes under, crunching up the towel until the whole towel is curled up



\_\_\_\_\_ Sets x  
\_\_\_\_\_ Reps

Marble Pick Ups

- While seated, place marbles on the floor and pick them up one by one using toes and place them in a cup



\_\_\_\_\_ Sets x  
\_\_\_\_\_ Reps

### Calf Stretch with Towel

- While seated with legs straight, place towel around foot and pull foot back towards body



\_\_\_\_\_ Sets x  
\_\_\_\_\_ Reps

### Wall 4-way with ankle

- While seated on floor with foot against wall, push against wall with foot
- While seated on floor with outside of foot against wall, push outward against wall with foot
- While seated on floor with inside of foot against wall (doorway), push inward against wall with foot
- While seated in chair, place foot under bed frame with top of foot touching the frame and pull foot upward against bed frame

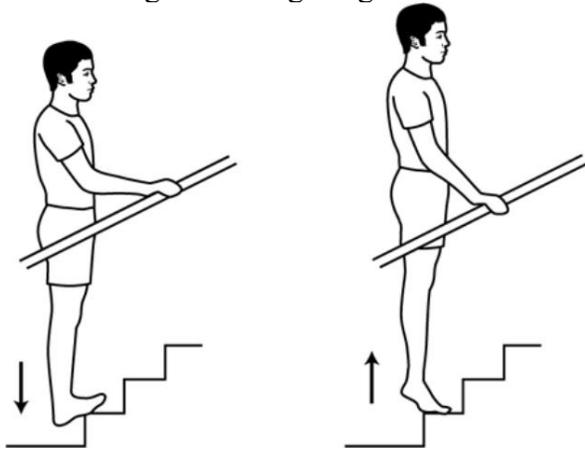


\_\_\_\_\_ Sets x  
\_\_\_\_\_ Reps



## 2 Leg Calf Raise

- Standing on both feet, lift heels upward and come back down
- Progress to single leg



\_\_\_\_\_ Sets x  
\_\_\_\_\_ Reps

## Single Leg Balance

- Stand on injured leg, keeping balance



\_\_\_\_\_ Sets x  
\_\_\_\_\_ Reps

Ice for 20 minutes twice per day to reduce pain

## Brace Suggestions

ASO® Ankle Stabilizer

<http://www.medspec.com/OnlineProducts.cfm?ID=1>

\$39.99

Mueller The One Ankle Brace

<http://www.muellersportsmed.com/the-one-ankle-brace.html>

\$39.99

APPENDIX E  
INSTRUMENT RELIABILITY

## FIGURE OF 8 RELIABILITY

### Examiner 1

	Test 1 Left	Test 1 Right	Test 2 Left	Test 2 Right
Subject #1	54.6	54.2	53.0	53.2
Subject #2	50.7	51.4	49.6	50.1
Subject #3	48.3	49.0	48.3	48.5
Subject #4	53.6	54.4	53.8	54.3

### Examiner 2

	Test 1 Left	Test 1 Right	Test 2 Left	Test 2 Right
Subject #1	52.7	53.0	52.8	53.0
Subject #2	48.6	48.7	48.5	48.3
Subject #3	48.1	48.7	48.8	48.7
Subject #4	53.0	53.3	42.6	53.3

### Examiner 3

	Test 1 Left	Test 1 Right	Test 2 Left	Test 2 Right
Subject #1	53.1	53.2	53.3	53.4
Subject #2	48.8	49.3	49.7	49.9
Subject #3	48.6	49.9	49.6	50.7
Subject #4	53.8	54.6	53.3	53.8

### Examiner 4

	Test 1 Left	Test 1 Right	Test 2 Left	Test 2 Right
Subject #1	52.6	52.6	52.2	52.8
Subject #2	48.5	48.4	48.3	48.1
Subject #3	48.3	48.3	48.7	48.8
Subject #4	53.6	52.6	51.8	52.3

### Intra-Rater Reliability

	Right Leg	Left Leg
Examiner 1	.990	.975
Examiner 2	.999	.992
Examiner 3	.975	.979
Examiner 4	.993	.987

### Inter-Rater Reliability

Test 1 Right Leg	Test 1 Left Leg	Test 2 Right Leg	Test 2 Left Leg
.985	.989	.982	.990

APPENDIX F  
POWER ANALYSIS

## POWER ANALYSIS

### Figure of 8 Measurement

Bleakley CM, McDonough SM, MacAuley DC. Cryotherapy for acute ankle sprains: a randomized controlled study of two different icing protocols. Br J Sports Med. 2006;40:700-705

$$(2.1-2.3)/((.12+.16)/2) = -1.43$$

Man I, Morrissey M, Cywinski J. Effect of neuromuscular electrical stimulation on ankle swelling in the early period after ankle sprain. Phys Ther. 2007;87:53-65.

$$(58.0-54.0)/((4.7+5.7)/2) = 0.77$$

Figure of 8 Measurement effect size average = 0.79

$$\text{Power} = 0.8$$

$$\text{Alpha} = .05$$

$$\text{Approximate subjects per group} = 20$$

### Foot and Ankle Disability Index – Sport

Brown C, Padua D, Marshall S, Guskiewicz K. Individuals with mechanical ankle instability exhibit different motion patterns than those with functional ankle instability and ankle sprain copers. Clin Biomech. 2008;23:822-831

$$(90.98-76.62)/((12.24+9.73)/2) = 1.3$$

Hale S, Hertel J, Olmsted-Kramer L. The effect of a 4-week comprehensive rehabilitation program on postural control and lower extremity function in individuals with chronic ankle instability. J Orthop Sport Phys. 2007;37(6):303-311

$$(11.1-2.63)/((15.86+7.54)/2) = 0.72$$

Foot and Ankle Disability Index – Sport effect size average = 0.76

Power = 0.8

Alpha = .05

Approximate subjects per group = 20

Based on an average effect size of 0.78, a power of 0.8, and an alpha level of 0.05, I propose the need for approximately 20 subjects per group.