EFFECTS OF A 4-WEEK GRASTON INSTRUMENT ASSISTED SOFT TISSUE TECHNIQUE IN INTERCOLLEGIATE ATHLETES WITH CHRONIC ANKLE INSTABILITY

by

Jeffrey Adam Jordan

A thesis submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Masters of Science in
Kinesiology

Charlotte

2015

Approved by:

____
Dr. Tricia Turner

____
Dr. Erik Wikstrom

____
Dr. Mike Turner

____
Dr. Abbey Thomas

ABSTRACT

JEFFREY ADAM JORDAN. Effects of a 4-week graston instrument assisted soft tissue technique in intercollegiate athletes with chronic ankle instability. (Under the direction of DR. TRICIA TURNER)

Context: Chronic Ankle Instability is a condition that has continued to be a problem in athletes. Additional rehabilitation protocols are still being evaluated to alleviate reoccurring ankle sprains. Graston Technique is an instrument-assisted soft-tissue mobilization that assists in the release of scar tissue and facial restriction. Objective: To examine the effects of Graston Technique compared to a SHAM with outcome measures of subjective function, balance, and range of motion in collegiate athletes with chronic ankle instability (CAI). Design: Pretest/posttest. Participants: Sixteen collegiate athletes with a history of chronic ankle instability. Participants were randomly assigned to a treatment (4 males, 4 females, weight: 73.43 ± 18.18 kg, height: 177.8 ± 7.68 cm, age: 20.0 ± 1.07 y) and control group (4 males, 4 females, weight: 80.25 ± 28.81 kg, height: 177.53 ± 11.30 cm, age: 19.75 ± .886 y). Outcome Measures: FAAM and FAAM Sport Subscale, Balance Error Scoring System, and Weight Bearing Lunge. Results: There were no significant differences between the treatment and control groups. Both the treatment and control groups significantly improved in subjective function, balance, and range of motion. Conclusion: Based on the current results Graston Technique was no more effective at improving subjective function, balance, and range of motion in collegiate athletes compared to SHAM treatment. Doing light massage to the lower extremity was as effective at improving outcomes as Graston Technique.

ACKNOWLEDGMENTS

I would like to thank the contributions of Drs. Tricia Turner, Erik Wikstrom, Michael Turner, and Abbey Thomas. Dr. Tricia Turner, thank you for everything you have done for me, it truly means a lot to always have someone to count on answering any question asked no matter the time of day. Thank you for staying on me with deadlines and being there for me every step of my academic and career paths. Dr. Erik Wikstrom, thank you for all the advice and reminders that you sent my way. I would not have made it this far without you. Dr. Michael Turner, thank you for being the extra support I needed in and out of the classroom. You truly did push me to my limit of knowledge and it made me the student I am today. Dr. Abbey Thomas, thank you for being the new face that added a different flavor to every topic. I am grateful to have such an outstanding group of researchers by my side along this journey. Thank you for everything, I will never forget it!

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

The acute ankle sprain is the most frequent orthopedic injury in intercollegiate athletics, accounting for 10% to 25% of all sports injuries.[41, 12] Chronic Ankle Instability (CAI) is a constraining condition often encountered after an ankle injury and is characterized by a reoccurring "giving away" of the ankle joint.[19, 35, 36, 28] The rate of reoccurring ankle sprains is 28.3% and is usually accompanied by CAI.[39] Usually the "instability" of the ankle joint occurs during walking, however in severe cases, it is seen in individuals while just standing. People with CAI usually complain of repetitive acute ankle injuries, giving way, consistent inflammation, and discomfort.[1, 3, 12, 18, 19, 41] Several obstinate complications such as high levels of chronic symptoms, decrease physical activity, recent injury, and functional abnormalities can obstruct ones ability to successfully complete activities of daily living or even participate in physical activity.[18, 25, 33, 41] Due to the high percentage of patients that develop CAI research is needed to better understand the most effective treatment and rehabilitation strategies.

Research has reported patients with CAI have neuromuscular impairments.[12, 19] These impairments include an inhibition of the open-loop (preparatory)[19] and closed-loop (reactive)[19] control as well as voluntary movements that work together to maintain proper joint alignment and stability in response to outside disturbances to the ankle joint.[12, 18, 19] In general, open-loop consist of anticipatory muscle activation while closed-loop control the reflex arc initiated after a stretch in muscle spindles and afferent signals have been stimulated.[12, 19] Numerous researchers have studied these reflexive impairments, yet there still is an uncertainty in the literature as to how exactly neuromuscular reflexes impact ankle sprains.[12, 18, 19] There have been several studies observing neuromuscular rehabilitation programs in preventing ankle sprains and improving function in those with CAI.[12, 15, 18, 19, 35, 37] With most research reporting the positive effects of balance training programs in those with CAI it is perceived that proprioceptive exercises enhance neuromuscular function.[35] To date there is limited research regarding the effectiveness of manual therapy techniques.[19] However, manual therapy techniques may be another method to improve neuromuscular function.

Graston Technique is an instrument-assisted soft-tissue mobilization that assists in the release of scar tissue and facial restriction.[41] The method employs a collection of six stainless steel instruments of particular size and contour that are used to manipulate a variety of soft tissue regions. Specific stroke patterns are used with the instruments in order to detect and relieve adhesions located in the muscles and tendons.[24, 34, 41] Graston Technique positively contributes to healing degenerative soft tissue by inducing controlled micro trauma while aiding to realign soft tissue fibers.[41] Health care providers must be licensed in Graston Technique in order to provide treatment to patients. Graston Technique is not a widely used manual therapy, but those who use it consist of physical therapists, athletic trainers, occupational therapists, hand therapists, and chiropractors.

Studies have reported that Graston Technique could improve inflammation, scar tissue build up, and muscle length in the healthy population.[24, 34, 41] Research is limited in the area of Graston Technique applied to intercollegiate athletes with CAI. One previous study reported Graston Technique to improve balance in subjects with CAI; however the study did not examine how long after treatment the improved balance lasted.[41] The study also demonstrated Graston Technique improved scores on the Foot and Ankle Ability Measure (FAAM) and FAAM Sports subscale subjective function questionnaire. There are few studies in younger patients with musculoskeletal pathologies; the majority of Graston research has not used intercollegiate athletes.[34, 41] Based on the limited research available, there is a need to further study examining Graston in patients with CAI.

The purpose of this study was to assess the effects of a 4-week Graston instrument assisted soft tissue technique in intercollegiate athletes with CAI and to determine if the effects last 2 weeks after treatment. We hypothesize that after a 4-week Graston assisted soft tissue technique intercollegiate athletes will experience improvement in balance, subjective function, and range of motion when compared to a SHAM. We also hypothesize that following a 2-week period of no treatment intercollegiate athletes will maintain improvements in balance, subjective function, and range of motion.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction / Epidemiology

Ankle sprains are the most common injury in intercollegiate sports today.[18, 19, 41] It is estimated that over 28,000 ankle sprains occur each day.[25] Millions of dollars are spent on the treatment of ankle sprains each year and contribute to a tremendous burden to the allied health profession.[25] If not properly treated and rehabilitated, a simple ankle sprain can turn into Chronic Ankle Instability (CAI). It is estimated that 20 to 40 percent of individuals that have experienced an ankle sprain will develop symptoms of CAI.[14, 41] Although not permanently disabling, an ankle sprain often plaques the athlete after recovery from initial injury. Typical symptoms include pain during activity, reoccurring swelling, feeling of “giving way” and weakness.[19, 41] Two theories have been identified that the cause of CAI is mechanical and/or functional instability. Mechanical instability of the ankle joint occurs due to anatomical insufficiencies that lead to future acute ankle injuries. These insufficiencies include pathological laxity, impaired range of motion (ROM), or arthokinematic impairments.[18, 19, 41] Functional instability of the ankle joint is typically caused by an injury to the lateral ligaments resulting in adverse changes to the neuromuscular complex of the ankle. Proprioceptive balance that has been inhibited due to a lateral ankle sprain eventually develops complications with articular mechanoreceptors. Despite the research efforts over the past 40 years, we still do not have a clear answer to the etiology of CAI.

2.2 Ankle Joint Anatomy

The ankle joint is formed by an association of two primary bones including the talus and calcaneus, which fit inside a socket formed by the tibia and fibula. The boney articulation is linked together by ligaments of various strength and patterns. The ankle joint is more than just your typical hinge or ball and socket joint.[22] It is a combination of both and is very complex in regards to its ligamentous and muscular make up. During the joints arc of motion, rolling and sliding occur simultaneously while joint surfaces articulate one another. The intricate balance of ligaments and muscles help stabilize the joint in order for complete range of motion to be established. The most important ligaments in the ankle joint are located on the lateral side consisting of the anterior talofibular ligament (ATFL), posterior talofibular ligament (PTFL), and calcaneofibular ligament (CFL). The ATFL originates on the anterior portion of the lateral malleolus and inserts on the talar neck. It is the first ligament to detect lateral external force applied even though it is considered the weakest.[16, 25] The ATFL restricts supination and anterior translation motions.[16] The PTFL originates on the posterior talus and inserts on the lateral malleolus (fibula). Its location is reflective of its mechanism and is the strongest ligament on the lateral aspect of the ankle joint. The CFL originates deep within the musculoskeletal make-up of the lateral ankle running from the fibula to the lateral tubercle of the calcaneous.[22] The lateral ligamentous complex of the ankle joint is commonly injured due to an inversion mechanism of injury.[25]

The ankle joint establishes motion with a series of muscles comprised of tendons. The achilles tendon is associated with the gastrocnemius muscle, which is commonly used for activities of daily living such as walking, running or jumping. It attaches to the calcaneal tuberosity and is responsible for plantar flexion. The peroneal (fibularis) muscle group primarily consists of the fibularis longus, fibularis brevis, and fibularis tertius. The peroneal longus muscle is responsible for plantar flexion and eversion of the ankle, while the peroneal brevis triggers eversion and peroneal tertius is responsible for dorsiflexion and eversion. The musculoskeletal arrangement within the ankle joint is essential after an acute ankle injury. Strengthening and proprioceptive exercises are vital measures of the rehabilitation and treatment protocol. With proper rehabilitation and treatment following an acute ankle injury the possibility of developing CAI is considerably decreased.[18, 41]

2.3 Causes of Chronic Ankle Instability

Mechanical Insufficiencies

Joint laxity and pain are often seen in acute ankle sprains and are widely examined in individuals with CAI.[16, 25] Joint laxity is typically measured through manual stress tests, stress radiography, and instrumented ankle arthrometers.[11] Mechanical instability of the talocrural and talocalcaneal articulations are related to acute ankle sprains due to the distraction of the three main ligaments of the lateral complex: anterior talofibular ligament, calcaneofibular ligament, and posterior talofibular ligament.[11] Specific arthrokinematic changes in the talocrural joint and its relation to ankle sprains include the restriction of a posterior talar glide due to an anterior positioned talus or changes in the position of the fibula.[14] Clinicians have successfully treated symptoms of ankle sprains with talus positioning along with several manual therapy techniques.[14] Acute ankle sprains are usually accompanied with inadequate treatment and rehabilitation and could lead to CAI.[11, 14]

Functional Insufficiencies

Neuromuscular inhibition has been feasibly recognized as one of the leading causes of CAI.[12, 19, 35] A clinical review by Gutierrez et al[3] helped explain the recent findings and assumptions of neuromuscular control and ankle instability. Gutierrez et al[19] concludes that CAI is a complex neuromuscular disorder, which affects a large group of individuals who have lateral ankle sprains. The complex reasoning behind neuromuscular reflex remains unclear, however, the combination of factors leading to the development of CAI consists of open and closed-loop control mechanisms.[19] Clinicians can now design a more suitable treatment and rehabilitation model, specifically directed towards neuromuscular inhibition.

Neuromuscular control can be defined as the interaction between the nervous and musculoskeletal systems in response to a stimulus.[19] Open-Loop control consists of the anticipatory muscle activation to prepare the muscle for the onset of a stimulus.[19] Closed-Loop control consists of a reflex arc initiated by the stimulus in order to produce an appropriate musculoskeletal response.[19] Neuromuscular open and closed loop firing patterns have been described as being altered or having an "electromechanical delay" after injury.[19] Damage to the mechanoreceptors located in the ligaments and/or muscles typically leads to deficits in somatosensory processing and neuromuscular control.[19, 31] For example, a rupture of the muscle spindle will inhibit muscle reactions and sensory feedback via the open and close loop control.[31]

Postural control can be measured and used to help detect ankle sprain risks as well as sensorimotor deficits after an acute ankle sprain in individuals with CAI.[28, 35, 37] Typical outcome measures testing that evaluates postural control consist of force plate measurements while performing a Romberg Test.[37] Several studies have been conducted in order to evaluate postural control, however it is difficult to effectively measure CAI status.[2, 15, 28, 42] Postural control measures have been seen to determine health status rather than used as a diagnostic tool.[28] Therefore, subjective function has been considered the standard for determining CAI when evaluating postural control.[28]

The Balance Error Scoring System (BESS) is commonly used by researchers and clinicians in order to accurately measure balance or postural control.[2] A growing number of studies are using the BESS as an outcome measure in a variety of chronic and acute conditions.[2] Docherty et al[15] assessed functional ankle instability through the BESS on intercollegiate athletes. The study showed that individuals with a history of ankle instability scored a significant amount of errors on the BESS when compared to the healthy control group. Additional studies also highlight the importance of static and dynamic balance when observing conditions of the lower leg.[6, 15, 42] The BESS is considered a reliable and valid outcome measure in assessing balance or postural control.[2, 45] BESS scoring errors are typically seen to increase with age and ankle instability and are seen to improve with training.[2, 15]

Researchers and clinicians commonly use the weight bearing lunge tests in order to accurately measure dorsiflexion range of motion in the ankle joint.[1, 7] Restrictions in dorsiflexion range of motion have been linked to many ankle abnormalities including CAI. A reduction in ankle dorsiflexion can cause additional abnormalities in the knee and also increase the rate of recurring ankle sprains.[1] The weight bearing lunge tests is usually measure one of two ways, with a goniometer or with a tape measurer measuring the distance from the toes to the wall while lunging against the same wall with the knee.[7]

The validity and reliability has been proven in that of the weight bearing lunge test.[7] It is widely used in research and is always a good tool to subsequently provide insight in regards to risk of ankle injury.[1, 7]

Proprioceptive deficits have been seen in individuals with ankle injuries due to altered neuronal firing and decreased sensory awareness.[17] Additional studies have described variations of proprioceptive deficits as postural sway, gait mechanics, and a decrease in dynamic stability with activities which place individuals at risk for re-injury.[17] Changes in strength with proprioception have also been mentioned in contribution to lower extremity biomechanics, which lead to ankle re-injury.[17] With the high risk of re-injury and possible development of CAI proper rehabilitation with strengthening and proprioception exercises are of the most importance.[17] Balance and coordination exercises are common components of rehabilitation and the recognition of acute ankle sprains or the development of CAI.[38]

2.4 Subjective Function

The Foot and Ankle Ability Measure (FAAM) and Foot and Ankle Ability Measure Sport Subscale (FAAMS) are regularly used questionnaires in research to evaluate ones subjected function.[8] The FAAM is a compiled list of questions that are related to normal activities of daily living while the FAAMS is a shorter list of questions that are related to sports related activities. The FAAMS is unique in that it is specifically designed for athletes.[8, 20] Despite the vast amount of research on the older and sedentary population, few researchers have addressed the use of athletes in outcome measurements.[20] The FAAM and FAAMS are considered valid and reliable tools in measuring subjective function in subjects with CAI.[8, 20]

2.5 Treatment of Chronic Ankle Instability

With the biggest impairments reported in patients with CAI being mechanical or functional in nature, treatments have focused on ways to improve both. Manual therapy is evolving as one of the most popular forms of treatment in individuals with CAI.[44] The importance of ankle dorsiflexion after acute ankle sprains or during CAI has been emphasized as a rehabilitation tool for proper recovery.[44]Ankle dorsiflexion can be achieved through static and dynamic stretching techniques or through joint mobilizations. Inadequate restoration of dorsiflexion in the ankle could lead to reoccurring ankle sprains, limited walking, limited jumping, and limited activities of daily living.[44] Insufficient range of motion (ROM) after an ankle sprain has been considered a predisposed factor of reoccurring ankle sprains due to the motion of dorsiflexion.[44] Diminished ankle dorsiflexion prevents the ankle from reaching its "closed-pack" position by holding the ankle in a hypersupination state.[44] Without proper rehabilitation, treatment of stretching, and joint mobilization reoccurring ankle sprains will continue to occur and develop into CAI.

Many athletes consider taping and bracing as a reliable source for the prevention of acute and chronic ankle injuries.[4] Athletes also believe that taping and bracing contributes to athletic performance. Functional performance effect of ankle taping and bracing has been evaluated in healthy and CAI individuals.[4] It has been described that taping and bracing is often used to prevent "giving way" in the joint of CAI individuals.[29] However, it is still unknown if bracing and taping completely prevent abnormal kinematics in CAI individuals. [29]

There have been numerous balance-training studies that have shown to improve balance as well as subjective function in those with CAI. Impairments in both static and dynamic balance have been emphasized in individuals with CAI.[1] Balance deficits are more than likely due to altered proprioceptive and neuromuscular control. These deficits are seen mostly during dynamic activities and continue to get worse if not treated.[1] A clinical evaluation of balance can be assessed by basic balance tests such as the Balance Error Score System (BESS) and the Star Excursion Balance Test (SEBT). [1] Balance and coordination training are two important interventions when applied to a treatment or rehabilitation program with acute ankle sprains or individuals suffering from CAI.[38] Additional research has hypothesized that balance exercises could diminish proprioceptive deficits and postural control issues associated with acute ankle sprains and CAI.[17, 28, 37, 38]

There are very few studies that have outlined the effectiveness of Graston Technique and its implication to CAI. Many of the articles in relation to Graston Technique and its positive manual therapy attributes have been focused around extremities and joints rather than the ankle. A recent study by Laudner et al[30] discovered that the acute effects of Graston Technique do improve posterior shoulder ROM in intercollegiate baseball players. A one-day treatment session with several stroke patterns over the posterior shoulder increased shoulder abduction, internal rotation, and external rotation range of motion in most of the subjects. Increasing ROM in any joint allows the surrounding muscles to relax and reflexively contract at an optimum length.[30] Graston Technique can also show benefits in post-operational situations such as mentioned in a study conducted by Black et al.[5] Weekly Graston Technique treatment sessions postoperation of a patella tendon rupture was seen to improve pain, ROM, activities of daily living, and strength. Even though all of these positive attributes were subjectively recorded, Graston Technique seems to have a progressive effect on acute and chronic conditions.

Based on the positive effect of Graston Technique reported in healthy subjects, or at other joints, the effects of Graston Technique need to be examined in subjects with CAI. A recent study performed by Schaefer et al[41] reported that Graston Technique implemented with a dynamic balance protocol could effectively improve self-reported function, pain, ROM, and dynamic balance in patients with CAI. Thirty-six healthy physically active individuals with a history of CAI participated in the study. All three groups either participated in low-impact and dynamic activities; low-impact and dynamic activities with Graston Technique or low-impact and dynamic activities with SHAM Graston Technique. The FAAM and FAAM-Sport subscales were used to accurately access the individual's subjective function.[8, 41] A majority of the subjects experienced a significant increase score in both FAAM and FAAM-Sport subscales. Even though improvements were seen in healthy physically active individuals with CAI, future research needs to be explored in Graston Technique. Since previous research has shown positive effects of Graston Technique and balance training in subjects with CAI, we would like to examine if Graston Technique alone has the same results. Rehabilitation time is limited, so if the same effects can be seen with just Graston Technique, more patients may be likely to stick to the rehabilitation plan. Another question that needs to be examined is if effective, how long does the effectiveness last?

2.6 Conclusion

CAI is continuing to be a significant problem in not only intercollegiate athletes, but also recreationally active patients. With such a high reported incidence and significant loss of function reported, finding treatments to help patients recover from CAI is critical. Early evidence has demonstrated Graston Technique to potentially be a manual therapy technique that may improve balance and subjective function in those with CAI. We plan on conducting a similar study but also try to examine how long the potential positive effects of Graston will last after treatment is complete.

CHAPTER 3: METHODS

3.1 Participants

Sixteen student athletes were recruited from the University of North Carolina at Charlotte athletic department. All subjects were randomly distributed into a treatment (4 males, 4 females, weight: 73.43 ± 18.18 kg, height: 177.8 ± 7.68 cm, age: 20.0 ± 1.07 y) and control (SHAM) (4 males, 4 females, weight: 80.25 ± 28.81 kg, height: 177.53 ± 11.30 cm, age: 19.75 ± .886 y) group. Subjects were participating in normal athletic practices and competitions involving the sports football, baseball, women's soccer, and volleyball. Subjects classified as having chronic ankle instability (CAI) met the following inclusion criteria: a history of at least 1 significant ankle sprain. The initial sprain had to occur at least 12 months prior to the study enrollment and was associated with pain, swelling, and was significant enough to interrupt at least 1 day of preferred physical activity. The subject had to report at least 2 incidences of the ankle "giving way" in the past 6 months. Lastly, subjects had to score less than 24 on the Cumberland Ankle Instability Tool (CAIT). Exclusion criteria included an ankle sprain (or any acute musculoskeletal injury to the lower limb) within the past 3 months; a history of previous surgery to either limb of the lower extremity, a history of fracture in either limb, or any neuromuscular disease/impairments.[23] The Institution Review Broad of the University of North Carolina at Charlotte approved this study.

3.2 Procedure

Before the study, after the completion of the Graston or SHAM treatment, and at follow-up (2-weeks) all subjects completed a laxity test, Foot and Ankle Ability Measure (FAAM) assessing subjective function, Balance Error Scoring System (BESS) assessing balance, and a weight bearing lunge test assessing range of motion.

Laxity of the ankle was assessed through a variety of special tests. The anterior drawer and talar tilt tests are typically used for evaluating the ligamentous integrity of the lateral aspect of the ankle. Each subject's laxity was evaluated before the treatment session, after, and two weeks after treatment stopped.

The FAAM consisted of a 21-item activity of daily living and a 7-item Sport subscale questionnaire that askes specific questions about the ankle and difficulty with certain activities.[32] The FAAM has been reported as a reliable, responsive, and valid measure of physical function for individuals with musculoskeletal pathology of the lower leg, foot, and ankle.[32, 41]

The BESS consist of a three-stance variation including double leg, single leg, and tandem stance. Each stance is performed on a firm surface and a foam surface with each trial lasting 20 seconds (Figures 1-6). Errors that are relevant to insufficient balance consist of moving of the hands off the hip, step/stumble, over abduction or flexion of the hip, or remaining out of proper position for more than 5 seconds. The BESS provides and effective and cost efficient objective method approach of assessing static postural stability.[15]

The weight bearing lunge tests is using in determining dorsiflexion range of motion in the ankle joint.[1, 7] The weight bearing lunge test is accomplished by first marking the ground with a piece of tape in order for the participant to have a starting point (Figure 7). The subject is to place their toes on the edge of the tape and flex the knee until it comes in contact with the wall (Figure 8). If the heel is conformability resting against the ground the toes can be placed further away from the wall or tape in order to achieve a greater dorsiflexion range of motion. In order to accurately measure ankle dorsiflexion with the weight bearing lunge test the distance from the toes and the wall must be measured. The measurement is not accurate when the heel is lifted off the ground while the knee is in contact with the wall. The weight bearing lunge test is valid and reliable when calculating ankle dorsiflexion in CAI patients.[1, 7]

3.3 Study Design

Participants of the study were randomly placed in one of two groups. The first group consisted of 8 randomly selected subjects with CAI that receive Graston Technique (GT) over the major muscle groups of the lower leg. The second group consisted of 8 randomly selected subjects with CAI that receive a SHAM Graston Technique over the major muscle groups of the lower leg. The study lasted 4-weeks containing three treatment sessions a week. For the Graston treatment group, each treatment session consisted of a total fifteen minutes including the application of a lubrication emollient and cleaning of the treated area. Graston Technique consists of six stainless steel instruments of particular shape and size used to manipulate individual muscles. In this study, the instruments G2, G3, and G4 were administered over specific muscles (Figure 9). Major muscles manipulated in the study consisted of the gastrocnemius, soleus, achilles tendon, paroneals, foot extensors, and foot flexors. Each muscle was influenced via three different stroke patterns including framing, fanning, and strumming. The GT instrument G2 was implemented through the framing stroke around the lateral malleolus (Figure 10), the G3 instrument was implement through the strumming stroke on each muscle (Figure 11), and the G4 instrument was implemented through the fanning stroke on each muscle (Figures 12). All stroke patterns were performed in all directions and consisted of 10 stroke motions. The treatment group received treatment similar to what you would receive in a clinical practice. For the SHAM group subjects completed the 4-week treatment 3 days a week for 15 minutes just like the experimental group. The same stroke patterns were performed but there was no pressure applied to the skin. After a four-week treatment (or SHAM treatment) subjects were tested again for balance, range of motion, and subjective function (FAAM and FAAM-Sport). Additionally, two weeks after completing either the Graston treatment or SHAM treatment subjects reported back for a follow-up FAAM, range of motion and BESS testing.

3.4 Data Analysis

All subject descriptive data was analyzed using one-way analysis of variance (ANOVA) between groups (CAI, SHAM). A two-way ANOVA (group x time) was used to determine if differences exist between the dependent measures (balance, subjective function, range of motion). An alpha-level of $p < 0.05$ was used to determine the significant effects for each analysis.

FIGURE 1: BESS double leg on firm surface

FIGURE 2: BESS single Leg on firm surface

FIGURE 3: BESS tandem stance on firm surface

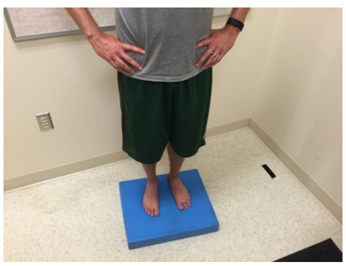

FIGURE 4: BESS double leg on foam surface

FIGURE 5: BESS single leg on foam surface

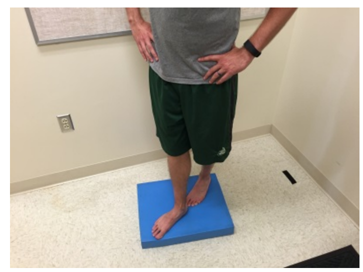

FIGURE 6: BESS tandem stance on foam surface

FIGURE 7: Weight bearing lunge test tape application

FIGURE 8: Weight bearing lunge test with heel down and knee touching wall

Figure 9: Graston Technique instruments GT 2, GT 3, and GT 4 with lubricant

Figure 10: Graston Technique instrument GT 2 with framing method

Figure 11: Graston Technique instrument GT 3 with strumming method

Figure 12: Graston Technique instrument GT 4 with fanning method

CHAPTER 4: RESULTS

Means and standard deviations for all variables are presented in Table 1. The average number of ankle sprains reported by the Graston Technique treatment group was 3 with a mean CAIT score of 16.63. The average number of ankle sprains reported by the SHAM treatment group was 2.75 with a mean CAIT score of 17.38. There were no group by time interactions for the FAAM ($F= .533$, $p = .593$) or the FAAM sport ($F= .387$, $p = .682$). There was a main effect for time. Between the pre-test and post-test subjects in both the treatment and control group saw significant improvements in both the FAAM ($F = 4.996$, $p = .014$) and FAAM sport ($F = 22.802$, $p = .001$) scores. There were no significant differences between the posttest and the 2-week after treatment posttest for either the FAAM ($F = .288$, $p = .600$) or FAAM sport ($F = .523$, $p = .481$). The subjects in both groups maintained the improvements in subjective function two weeks after treatment had stopped excluding the SHAM group in FAAM. Although not statistically significant, the control group mean FAAM score decreased from immediately after SHAM treatment to two weeks after treatment (79.25 vs. 77.00), while the treatment group score continued to increase 2-weeks after Graston treatment had ended (81.87 vs 83.00).

For the BESS measurements, there was no significant group by time interaction for any of the variables. Subjects in both groups had no errors on the firm or foam surface for double leg stance. There were significant main effects for time for the firm single leg stance ($F = 7.859$, $p = .002$), firm tandem stance ($F = 4.979$, $p = .014$), foam single leg stance ($F = 42.148$, $p = .001$), and foam tandem stance ($F = 8.240$, $p = .002$). Between the pre-test and the posttest measures, subjects in both groups had significantly less errors in the variables described above. For the firm single leg stance ($F = .010$, $p = .921$), the firm tandem stance (F.044, $p = .837$) and the foam tandem stance ($F = .214$, $p = .631$), there were no significant differences for either group between the 4-week posttest and the 2-week after treatment posttest. The foam single leg stance ($F = 9.00$, $p = .010$) had less errors when compared to the 4-week posttest. The subjects in both groups maintained the improvements in balance two weeks after treatment had stopped excluding the SHAM group in tandem stance firm/foam. The means and standard deviation for single leg (SL) and tandem stance (TS) variables are presented in Table 2 and 3.

There were no significant group by time interactions for the weight bearing lunge test ($F = .432$, $p = .654$). There was a main effect for time. Subjects in both groups had significantly more ($F = 13.128$, $p = .001$) dorsiflexion motion from between the pre-test and the posttest. There was no significant difference ($F = .049$, $p = .828$) between posttest and the 2-week after treatment posttest. The subjects in both groups did not maintain improvements in range of motion two weeks after treatment had stopped. The means and standard deviation of weight bearing lunge test variables are presented in Table 4.

TABLE 1: Mean ± SD of FAAM and FAAM Sport: Graston and SHAM treatment

	FAAM Pre-Test *	FAAM Post-Test *	FAAM 2-Weeks Post	FAAM Sport Pre-Test *	FAAM Sport Post-Test *	FAAM Sport 2-Weeks Post
Graston	77.6 ± 3.38	81.9 ± 1.73	83.0 ±1.60	21.8 ± 2.76	26.6 ± 1.41	26.9 ± 1.55
SHAM	73.9 ± 7.62	79.3 ± 6.65	77.0 ±10.9	17.5 ± 6.05	23.9 ± 5.14	24.1 ± 5.54

*Denotes statistically significant FAAM (p = 0.014) and FAAM Sport (p = 0.001)

TABLE 2: Mean ± SD of BESS SL firm and foam: Graston and SHAM treatment

	BESS (Firm SL) Pre-Test *	BESS (Firm SL) Post-Test *	BESS (Firm SL) 2-Week Post	BESS (Foam SL) Pre-Test *	BESS (Foam SL) Post-Test *	BESS (Foam SL) 2-Week Post
Graston	3.00 ± 1.51	1.38 ± 1.41	1.13 ± 1.36	6.50 ± 1.93	3.25 ± 1.28	2.50 ± 1.20
SHAM	2.50 ± 2.73	.750 ± 1.04	.750 ± .707	5.38 ± 2.62	4.63 ± 1.60	4.38 ± .518

*Denotes statistically significant BESS firm SL (p = 0.002) and foam SL (p = 0.001)

TABLE 3: Mean ± SD of BESS TS firm and foam: Graston and SHAM treatment

	BESS (Firm TS) Pre-Test *	BESS (Firm TS) Post-Test *	BESS (Firm TS) 2-Week Post	BESS (Foam TS) Pre-Test *	BESS(Foam TS) Post-Test*	BESS (Foam TS) 2-Week Post
Graston	.875 ± 1.25	.375 ± .744	.375 ± .518	2.50 ± 1.41	1.13 ± 1.55	1.00 ± .926
SHAM	1.13 ± 1.36	000 ± 000	.500 ± .535	2.88 ± 2.30	.750 ± 1.04	.875 ± 1.25

*Denotes statistically significant BESS firm TS (p = 0.014) and foam TS (p = 0.002)

TABLE 4: Mean ± SD of weight bearing lunge: Graston and SHAM treatment (cm)

	Lunge Pre-Test *	Lunge Post-Test *	Lunge 2-Weeks Post
Graston	6.87 ± 3.09	10.44 ± 3.87	9.50 ± 4.85
SHAM	7.75 ± 2.51	10.19 ± 2.95	10.06 ± 4.33

* Denotes statistically significant weight bearing lunge (p = 0.001)

CHAPTER 5: DISCUSSION

The results from this study demonstrated that collegiate athletes with chronic ankle instability (CAI) had significant improvements in subjective function, balance, and range of motion during a 4-week Graston Technique treatment session as well as the SHAM treatment. We were surprised that there were no differences between the SHAM and Graston groups as we hypothesized subjects receiving the Graston treatment would have significant improvements in outcome variables over the 4 week treatment period when compared to the SHAM treatment. Therefore, our hypothesis was not supported by the results. There were statistically no significant differences between the posttest and 2-week after treatment with subjective function, balance, and range of motion. However, Graston Technique and SHAM treatment groups maintained improvements after a two-week period of no treatment. In the Graston Technique treatment group FAAM, FAAMS, BESS single leg firm, BESS single leg foam, BESS tandem stance firm, and BESS tandem stance foam all maintained improvements during a 2-week period of no treatment. In the SHAM treatment group FAAMS, BESS single leg firm, and BESS single leg foam maintained improvements during a 2-week period of no treatment. It appears that not only do both Graston and SHAM treatment of light massage improve function, but those improvements were maintained 2-weeks after treatment has stopped.

5.1 Relationship with Other Studies

Schafer et al[41] reported improvements in subjective function, dynamic postural control, and range of motion during a 4-week treatment periodof Graston Technique. Subjects with CAI were randomized into three groups: dynamic balance training and graston technique, dynamic balance training and SHAM, and dynamic balance training only. The author's hypothesized subjects in the Graston Technique with dynamic balance training group would show more improvements than the other groups. Not one of the groups showed more significant improvements than the other. The results found in the Schafer et al[41] study were similar to the results in the current study in that we saw improvements in both the treatment Graston and SHAM groups. Graston Technique showed no more improvement when compared to a basic SHAM treatment of light massage. Schafer et al[41] utilized the same SHAM technique as the current study, however used an additional instrument (GT 5) and measured range of motion through a non-weight bearing method. Balance was assessed through the Star Excursion Balance Test (SEBT) when compared to our current study of the Balance Error Scoring System (BESS). In our study we did not use accompanying treatment methods such as a dynamic balance-training program when compared to Schafer et al.[41] Also, in the current study we recruited collegiate athletes instead of physically active high school students.[41] Both Schafer et al[41] and the current study reported improvements in subjective function, balance, and range of motion (both weight-bearing and non-weight bearing) however, the SHAM group was just as effective.[41] The results of our study demonstrated Graston Technique as well as light massage have a positive effect on a static balance task, however they both had equal outcomes, resulting in Graston Technique being less effective. With the results of the

Schafer et al[41] study showing similar results on a dynamic balance task, light massage or Graston Technique may be another tool to use as part of the rehabilitation plan to improve postural control in those with CAI.

5.2 Mechanisms for Improvements

Improvements that were seen in the Graston Technique treatment group and/or SHAM group could be related to improvements in mechanical and functional insufficiencies. Recurring ankle sprains can be caused by arthrokenimatic impairments, pathologic laxity, synovial changes, and neuromuscular control deficits.[11, 12, 19, 22, 35] The improvement in subjective function, balance, and range of motion reported in the current study, may have been due to consistent breaking up of small adhesions in the ligament and muscle, lengthening of the muscle belly and tendons, and repetitive sensory interaction. Research studies have demonstrated that Graston Technique can help loosen adhesions in the muscle belly and ligaments.[30, 35] Releasing adhesions can improve range of motion by elongating the muscle resulting in an increase dorsiflexion of the ankle. The SHAM group in the current study consisted of a light massage, which could also see improvements in adhesions in the muscle belly, tendons and ligaments. Graston Technique also seemed to reeducate neuromuscular control deficits by improving firing patterns and postural control. Consistent manipulation of the muscles and ligaments with the Graston Technique instruments improved balance through stimulation of the mechanoreceptors. Mechanical insufficiencies were not measured in this study, making the impairments of our subjects unknown; however, all of these positive attributes may have contributed to the improvement of the outcome measures.

Recurring ankle sprains can be associated with deficits in the nervous and musculoskeletal systems response to a stimulus.[19] With a light massage of the Graston Technique instruments, the “electromechanical delay” caused after an injury, can be resolved by manipulating the mechanoreceptors.[19, 31] There is little evidence to support Graston Technique and its contributions to electromechanical delay. Mechanoreceptors have long been studied as an important source to standing balance.[27] Lightly massaging various aspects of the lower leg and foot stimulate the cutaneous mechanoreceptors resulting in improving balance and localized pain.[46] Manipulation of mechanoreceptors can cause a relaxation of muscles and cause pain to decrease.[10] Repetitive light massage with the Graston Technique instruments improved subjective function, balance, and range of motion by increasing blood flow, and decreasing general pain.[9, 13, 21, 40] Recent studies suggest that an increase blood flow due to massage is a viable asset to improving balance.[9] Blood flow, muscle length, and general pain were not considered outcome measures in this current study, however these attributes can positively contribute to subjective function, balance, and range of motion.[40]

5.3 Massage Therapy vs. Graston Technique

Recent research is investigating that massage therapy can have similar effects on functional and mechanical insufficiencies, as does Graston Technique.[9, 13, 21, 40] Massage therapy has been researched to improve range of motion, strength, pain, and balance.[9, 13, 21, 40] Halperin et al[21] recently discovered that a “roller massager” improved range of motion and maximal force contraction in dorsiflexion of the ankle joint.[21] The SHAM treatment group in our study received a similar massage treatment as this study. Halperin et al[21] used a roller massager while we used the Graston Technique instruments. Pressure applied to the skin with a roller massage is comparable to the pressure with used in this current study. A recent study conducted by Skarabot et al[43] showed that light massage and foam rolling can increase dorsiflexion range of motion assessed through a weight bearing lunge test but the study did not re-evaluate range of motion after a period of no treatment. Graston Technique has also been directly correlated to massage and its ability to increase muscle temperature. With an increase in treatment time, the temperature also increases with massage and Graston Technique treatment. As a result in an increase in temperature blood flow will also increase.[40] Based on the results of this study there were no differences between the groups. You may not need the instruments used in Graston to cause improvements in some of the insufficiencies reported in subjects with CAI. Lightly massaging with hands or instruments may both be enough to cause a positive response.

5.4 Two-Week Period of No Treatment

In this study our hypothesis was supported by the results, both the Graston Technique and SHAM treatment maintained improvement seen during treatment after a 2-week period of no treatment in most dependent variables. Some variables actually continued to get better during the two week period of no treatment. Graston Technique maintained improvements in the FAAM, FAAMS, and BESS firm/foam, while the SHAM group maintained improvements in FAAMS, and BESS single leg firm/foam. Improvements were not maintained with range of motion in both groups. There was only a slight decrease in the weight bearing lunge test for both groups.

FAAM and BESS tandem stance firm/foam did not maintain improvements in the SHAM group. This may indicate that the SHAM was less effective in maintaining improvements in subjective function and balance when compared to the Graston

Technique group. Graston Technique was the only treatment protocol that we used in this current study to help improve our outcome measurements. In a clinical setting several treatment protocols will be combined in order to establish improvements. Recent studies on Graston Technique investigate several treatment protocols combined with Graston Technique to evaluate outcome measures, but did not have a period of no treatment.[30, 34, 41] With several treatment options available in a clinical setting, outcome measurements such as subjective function, balance, and range of motion could be properly maintained or even see additional improvements.

5.5 Clinical Implications

Considering that both Graston Technique and SHAM treatment groups both had equal improvements in our study, it is apparent that light massage of the lower leg and ankle is clinically a more efficient treatment and rehabilitation protocol. In order to perform Graston Technique clinically one must be certified in how to properly utilize the instruments. The instruments themselves are very expensive and can only be ordered if a health care provider is certified after taking a 12-hour course, however, Graston Technique instruments tend to save the hands of the clinician due to the amount of patients seen in one day. Light manual massage and even a “roller massager” is considered cheaper and more easily available in a clinical environment.[42] If both Graston Technique and SHAM treatments have the same outcome, light massage is more efficient, cost effective, and applicable to the clinical practice. However, since both appear to work, the clinician can select the technique that works best for them and the patient.

If periods of no treatment are reached in a clinical setting Graston Technique has shown in this current study that improvements can be maintained in subjective function, and balance up to 2-weeks after treatment. Light massage also showed its benefits to maintaining improvements, however was less effective in several areas. Graston Technique may be more beneficial in a clinical setting with periods of no treatment. Based on the results of the study clinicians can stop performing Graston or light massage on patients for at least two weeks, and the improvements from the treatment is maintained. Further research will need to determine how much longer after two weeks these improvements are maintained before more treatment may need to be given.

5.6 Limitations

Limitations of this study were the ability to recruit collegiate athletes. This research was conducted at the University of North Carolina at Charlotte. Recruiting student athletes for this study was very difficult due to their competition/travel schedule in combination with class schedule. With the frequency and duration of the study at a high demand, getting student athletes to voluntarily commit to the study was difficult. The potential participants would view the inform consent and immediately withdraw their name from the study before beginning. We had no problem finding collegiate athletes with CAI or getting them interested in the study, the problem was consistently have them commit to the frequency and duration of the study before it even began. We only recruited 16 of the proposed 30 collegiate athletes for this study due to this limitation.

5.7 Future Research

While our study answered the primary questions asked of Graston Technique in collegiate athletes with CAI it is safe to say that future research is needed. Future research should focus on comparing Graston Technique instruments to basic tools of any kind. It would be advantageous to evaluate a similar instrument in shape and size while comparing the outcome measures. Additional research could be focused on comparing CAI in collegiate athletes to a non-athlete population. It would be interesting to see if the outcome measures chosen for this research topic would have significant differences between the groups. Additional research ideas consist of multiple treatment-based protocols used in correlation with non-treatment sessions. Can multiple treatments (including Graston Technique) help maintain improvements of outcome measurements during larger periods of non-treatment in CAI athletes?

CHAPTER 6: CONCLUSION

In conclusion, a 4-week Graston Technique and SHAM treatment showed significant improvements in subjective function, balance, and range of motion in collegiate athletes with CAI. There were no statistically significant differences between posttest and the 2-week after treatment posttest. This indicates that Graston Technique as well as light massage can be beneficial in the population of collegiate athletes with CAI. While both groups showed improvements with treatment, several improvements were also maintained after treatment stopped.

REFERENCES

1. Basnett CR, Hanish MJ, Wheeler TJ, Miriovsky DJ, Danielson EL, Barr JB, Grindstaff TL. Ankle Dorsiflexion Range of Motion Influences Dynamic Balance in Individuals with Chronic Ankle Instability. *International Journal of Sports Physical Therapy.* 2013: 121-128.

2. Bell DR, Guskiewiez KM, Clark MA, Padua DA. Systemic Review of the Balance Error Scoring System. *Journal of Sports Science.* 2011: 287-295.

3. Benazzo F, Zanon G, Marullo M, Palol Rossi SM. Lateral Ankle Instability in High Demand Athletes: Reconstruction with Fibular Periosteal Flap. *International Orthopedics.* 2013: 1839-1844.

4. Bicici S, Karatas N, Baltaci G. Effects of Athletic Taping and Kinesotaping on Measurements of Functional Performance in Basketball Players with Chronic Inversion Ankle Sprains. *Journal of International Sports Physical Therapy.* 2012: 154-166.

5. Black DW. Treatment of Knee Arthrofibrosis and Quadriceps Insufficiency After Patellar Tendon Repair: A Case Report Including Use of the Graston Technique. *International Journal of Therapeutic Massage and Bodywork.* 2010: 14-21.

6. Bressel E, Yonker JC, Kras J, Heath EM. Comparison of Static and Dynamic Balance in Female Collegiate Soccer, Basketball, and Gymnastic Athletes. *Journal of Athletic Training.* 2007: 42-46.

7. Calatayud J, Martin F, Gargallo P, Garcia-Redondo J, Colado JC, Martin PJ. The Validity and Reliability of a New Instrument Device for Measuring Ankle Dorsiflexion Range of Motion. *International Journal of Sports Physical Therapy.* 2015: 197-202.

8. Carcia CR, Martin RL, Drouin JM. Validity of the Foot and Ankle Ability Measure in Athletes with Chronic Ankle Instability. *Journal of Athletic Training.* 2008: 179-183.

9. Chatchawan U, Eungpinichpong W, Plandee P, Yamauchi J. Effects of Thai Foot Massage on Balance Performance in Diabetic Patients with Peripheral Neuropathy: A Randomized Parallel-Controlled Trial. *Med Sci Monit Basic Res:* 2015: 68-75.

10. Cherkin DC, Sherman KJ, Kahn J, Erro JH, Deyo RA, Haneuse SJ, Cook AJ. Effectiveness of Focused Structural Massage and Relaxation Massage for Chronic Low Back Pain: Protocol for a Randomized Controlled Trial. *BioMed Central Trails*. 2009: 96.

11. Cordova ML, JoEllen SM, Hubbard TJ. Mechanical Joint Laxity Associated with Chronic Ankle Instability. *Sports Health Journal.* 2010: 452-459.

12. Coughlan G, Caulfield B. A 4-Week Neuromuscular Training Program and Gait Patterns at the Ankle Joint. *Journal of Athletic Training.* 2007: 51-59.

13. Crothers A, Walker B, French SD. Spinal Manipulative Therapy Versus Graston Technique in the Treatment of Non-Specific Thoracic Spine Pain: Design of a Randomized Controlled Trial. *Journal of Chiropractic Osteopat.* 2008: 16:12.

14. Croy T, Cosby NL, Hertel J. Active Ankle Motion May Result in Changes to the Talofibular Interval in Individuals with Chronic Ankle Instability and Ankle Sprain Copers. *Journal of Manual Manipulattive Therapy.* 2013: 122-133.

15. Docherty CL, Valovich TC, Shultz SJ. Postural Control Deficits in Participants with Functional Ankle Instability as Measured by the Balance Error System. *Clinical Journal of Sports Medicine.* 2006: 203-8.

16. Fong TP, Chan YY, Mok KM, Yung SH, Chan KM. Understanding Acute Ankle Ligamentous Sprain Injury in Sports. *Sports Medicine Arthroscopic Rehabilitation Therapy Technology.* 2009: 1-14.

17. Fulton J, Wright K, Kelly M, Zebrosky B, Zanis M, Drvol C, Bulter R. Injury Risk is Altered by Previous Injury: A Systemic Review of Literature and Presentation of Causative Neuromuscular Factors. *International Journal of Sports Physical Therapy.* 2014: 583-595.

18. Gribble PA, Hertel J, Denegar CR, Buckley WE. The Effects of Fatigue and Chronic Ankle Instability on Dynamic Postural Control. *Journal of Athletic Training.* 2004: 321-329.

19. Gutierrez GM, Kaminski TW, Douex AT. Neuromuscular Control and Ankle Instability. 2009: 359-365.

20. Hale SA, Hertel J. Reliability and Sensitivity of the Foot and Ankle Disability Index in Subjects with Chronic Ankle Instability. *Journal of Athletic Training.* 2005: 35-40.

21. Halperin I, Aboodarda SJ, Button DC, Anderson LL, Behm DG. Roller Massager Improves Range of Motion of Plantar Flexor Muscles Without Subsequent Decreases in Force Parameters. *International Journal of Sports Physical Therapy.* 2014: 92-102.

22. Hertel J. Functional Anatomy, Pathomechanics, and Pathophysiology of Lateral Ankle Instability. *Journal of Athletic Training.* 2002: 364-375.

23. Hiller CE, Refshauge KM, Bundy AC, Herbert RD, Kilbreath SL. The Cumberland Ankle Instability Tool: A Report of Validity and Reliability Testing. *Archives of Physical Medicine and Rehabilitation.* 2006: 1235-1241.

24. Howitt S, Wong J, Zabukovec S. The Conservative Treatment of Trigger Thumb Using Graston Technique and Active Release Techniques. *The Journal of the Canadian Chiropractic Association.* 2008: 249-254.

25. Kaminski TW, Hertel J, Amendola N, Docherty CL, Dolan MG, Hopkins JT, Nussbaum E, Poppy W, Richie D. National Athletic Trainers Association Position Statement: Conservative Management and Prevention of Ankle Sprains in Athletes. *Journal of Athletic Training.* 2013: 528-545.

26. Kanamoto T, Shioozaki Y, Horibe S. The Use of MRI in Pre-Operative Evaluation of Anterior Talofibular Ligament in Chronic Ankle Instability. *Bone and Joint Res.* 2014: 241-245.

27. Kennedy PM, Inglis TJ. Distribution and Behavior of Glabrous Cutaneous Receptors in the Human Foot Sole. *Journal of Physiology.* 2002: 995-1002.

28. Knapp D, Sae Yong Lee, Chinn L, Saliba SA, Hertel J. Differential Ability of Selected Postural Control Measures in the Prediction of Chronic Ankle Instability Status. *Journal of Athletic Training.* 2011: 257-262.

29. Kobayashi T, Saka M, Suzuki E, Yamazaki N, Suzukawa M, Akaike A, Shimizu K, Gamada K. The Effects od Semi-Rigid Brace or Taping on Talcrural and Subtalar Kinematics in Chronic Ankle Instability. *Foot and Ankle Specialists.* 2014: 471-477.

30. Laudner K, Compton BD, McLoda TA, Walters, CM. Acute Effects of Instrument Assisted Soft Tissue Mobilization for Improving Posterior Shoulder Range of Motion in Collegiate Baseball Players. *International Journal of Sports Physical Therapy.* 2014: 1-7.

31. Levin O, Vanwanseele B, Thijsen JR, Helsen WR, Staes FF, Duysens J. Proactive and Reactive Neuromuscular Control in Subjects with Chronic Ankle Instability: Evidence from a Pilot Study on Landing. *Gait and Posture.* 2014: 106-111.

32. Martin RL, Irrgang JJ, Burdett Rg, Conti SF, Van Swearingen JM. Evidence of Validity for the Foot and Ankle Ability Measure (FAAM). *Foot and Ankle Institute.* 2005: 968-983.

33. Mau H, Baker, RT. A Modified Mobilization With Movement to Treat a Lateral Ankle Sprain. *International Journal of Sports Physical Therapy.* 2014: 540-548.

34. Miners Al, Bougie TL. Chronic Achilles Tendinopathy: A Case Study of Treatment Incorporating Active and Passive Tissue Warm-Up, Graston Technique, ART, Eccentric Exercise, and Cryotherapy. *The Journal of the Canadian Chiropractic Association.* 2011: 269-279.

35. O'Driscoll J, Kerin F, Delahunt E. Effect of a 6-Week Dynamic Neuromuscular Training Program on Ankle Joint Function: A Case Report. *Sports Medicine Arthroscopy Rehabilitation Therapy Technology.* 2011: 1758-2555.

36. Olmsted LC, Carcia CR, Hertel J, Shultz SJ. Efficancy of a Star Excursion Balance Test in Detecting Reach Deficits in Subjects with Chronic Ankle Instability. *Journal of Athletic Training.* 2002: 501-506.

37. OMcKeon P, Hertel J. Systemic Review of Postural Control and Lateral Ankle Instability, Part 1: Can Deficits be Detected with Instrumented Testing. *Journal of Athletic Training.* 2008: 293-304.

38. OMcKeon P, Hertel J. Systemic Review of Postural Control and Lateral Ankle Instability, Part 2: Is Balance Training Clinically Effective. *Journal of Athletic Training.* 2008: 305-315.

39. Pietrosimone BG, Gribble PA. Chronic Ankle Instability and Corticomotor Excitability of Fibularis Longus. *Journal of Athletic Training.* 2012: 621-626.

40. Portillo-Soto A, Eberman LE, Demchak TJ, Peebles C. Comparison of Blood Flow Changes with Soft Tissue Mobilization and Massage Therapy. *Journal of Altern Complement Medicine.* 2014: 932-6.

41. Schaefer JL, Sandrey MA. Effects of a 4-Week Dynamic-Balance-Training Program Supplemented With Graston Instrument-Assisted Soft-Tissue Mobilization for Chronic Ankle Instability. *Journal of Sport Rehabilitation.* 2012: 313-326.

42. Scott RE, Guskiewicz KM. Examination of Static and Dynamic Postural Stability in Individuals with Functionally Stable and Unstable Ankles. *Journal of Sports Medicine.* 2004: 332-338.

43. Skarabot J, Beardsley C, Stirn I. Comparing the Effects of Self-Myofascial Release with Static Stretching on Ankle Range of Motion in Adolescent Athletes. *International Journal of Sports Physical Therapy.* 2015: 203-212.

44. Terada M, Pietrosimone BG, Gribble PA. Therapeutic Interventions for Increasing Ankle Dorsiflexion After Ankle Sprain: A Systematic Review. *Journal of Athletic Training.* 2013: 696-709.

45. Wilkins JC, Valovich TC, Perrin DH, Gansneder BM. Performance on the Balance Error Scoring System Decreases After Fatigue. *Journal of Athletic Training.* 2004: 156-161.

46. Wikstrom EA, LeClaire JE. Massage for Postural Control in Individuals with Chronic Ankle Instability. *Research Gate.* 2012: 213-219.

APPENDIX A: INFORMED CONSENT

UNC CHARLOTTE
College of Health and Human Services

Department of Kinesiology

9201 University City Blvd, Charlotte, NC 28223-0001
T704/687.6202

Informed Consent for
Effects of a 4-Week Graston Instrument Assisted Soft Tissue Technique in Intercollegiate Athletes with Chronic Ankle Instability

Project Title and Purpose

You are invited to participate in a research study entitled "Effects of a 4-Week Graston Instrument Assisted Soft Tissue Technique in Intercollegiate Athletes with Chronic Ankle Instability". This is a study to determine the effects of a Graston instrument assisted soft tissue technique in athletes with chronic ankle instability. The effects of this treatment will be measured in order to determine if it specifically improves subjective function and/or balance.

Investigator(*s*)
This study is being conducted by Jeffrey Adam Jordan and Dr. Tricia H Turner in the Department of Kinesiology at UNC Charlotte.

Eligibility
To participate in the study you have to fit into the following group:

Inclusion Criteria:

- Student Athlete that is currently enrolled in classes at the University of North Carolina at Charlotte
- Currently experiencing chronic ankle instability in one ankle. This includes those that have a history of ankle sprains in either the right or left ankle. Additionally you feel that your ankle is unstable and gives way. You may have ankle pain and feel your ankle is weaker.
- Between the age of 18-25 years old

Exclusion criteria:

- Under the age of 18 or older than 25
- Ankle injury within the past 6 weeks
- Ankle fractures
- Ankle surgery
- Non-UNC Charlotte student athlete

Overall Description of Participation

If you are interested in participating in the study you will report to the athletic training room at the Judy W. Rose Football Center. You will first sit down with the investigator and review the consent form. If you qualify to the inclusion criteria you will remain in the study and continue the study. If you qulify to the exclusion criteria your participation to the study will end at that time. Please be aware that this study will not impact your academic or athletic status in any way.

In this study you will be placed into one of two groups: intervention group or the control group. The intervention group will receive the full Graston Technique treatment while the conrol group will only receive a mimic on the Graston Technique.

The first session will last approximately 30 minutes. In order to determine if you have chronic ankle instability (CAI) you will need to fill out the Cumberland Ankle Instability Tool (CAIT), this questionnaire will ask about how your ankle feels. Two test will be performed in order to test the amount of movement or laxity in your ankle. The anterior drawer and talar tilt tests are painless and will only take a few minutes to perform. For the anterior drawer test, I will place my hands around your ankle and pull forward, for the talar tilt I turn your ankle in and out. There should be no pain with these tests. In order to determine the amount of sensation in the lower leg a set of Weinsetin Monofilaments will be used. A monofilament tip will be placed directly on the bottom of your foot in five different loactions. Your eyes will be closed for the duration of the test and you will let the investigator know everytime sensation is felt. There will be no pain with the testing of sensation while using the Weinsetin Monofilaments. Weight bearing range of motion (ROM) will be tested only on the involved (CAI) limb using the weight bearing lunge test (WBLT) which uses the knee to wall principle. During all trials, you will keep your heel firmly planted on the floor while flexing your knee to the wall. The non-test limb will be freely positioned behind the test limb based on comfort and will be used to maintain stability. When you are able to maintain heel contact and touch the wall with your knee, you will then move away from the wall and the modified lunge will be repeated until you cannot maintain the proper position. The monofilaments and WBLT will be shown to you and you will be able to ask any questions before testing begins.

You will then fill out the Foot and ankle ability measure (FAAM) and participate in the Balance Error Scoring System (BESS) . The FAAM asks questions about how your ankle is able to do activities of daily living as well as sports. You can ask the investigator questions as you go through the questionnaire. The BESS is a method of assesing balance through three various positions. The three stances incorporate the feet/legs in a postion of shoulder width, one legged, and one foot in front of the other. You will be asked to maintain those three positions as you balance on an even surface (the floor) and uneven surface (you will stand on a pad of foam) for 20 total seconds. After you are finished with the FAAM questionnaire and BESS, the first Graston Technique treatment session will begin. Each treatment session consists of a total eight minutes of treatment including the application of a lubrication emollient and cleaning of the treated area. The emollient lubricate consist of a mineral vitamin E based massage cream whereas the disinfectant consists of Ethyl Rubbing Alcohol that will come in direct contact with the skin.

Graston Technique consists of six stainless steel instruments of particular shape and size used to manipulate individual muscles around your lower leg and ankle. The investigator will show you all the instruments and demonstrate everything that will be done during the treatment session. Graston Technique is not approved by the Food and Drug Administration (FDA), but is classified as medical instruments and is exempt from FDA requirements. The Graston Technique instruments are only used under the recommendations of the Graston Technique Company. Major muscles that we will be manipulating will consist of the gastrocnemius, soleus, achilles tendon, peroneal tendons, foot extensors, and foot flexors. Each muscle will be influenced via three different stroke patterns including framing, fanning, and strumming. All stroke patterns will be performed in all directions and consisted of 10 stroke motions. You will be finished for the day after completion of the treatment session. If you have any pain or increase symptoms during the treatment let the investigator know so they can decrease the amount of pressure provided to the skin. You will then return for 2 more times that week, and then three more weeks of treatment three times a week. After your last treatment you will return (within 1 – 2 days) and again 2 weeks after treatment to fill out the FAAM and complete the same balance testing you performed before the study began. If you have any questions during the study do not hesitate to ask.

Length of Participation

Subjects will have to come to the Judy W. Rose Football Center Athletic Training Room 14 total times. The initial session and treatment session 1, followed by 11 other treatment sessions (three days a week for a total of 4 weeks) then a follow up 1 – 2 days after the last treatment session, and one follow up two weeks after the last treatment session. The first session will take 30 minutes while the remaining sessions will last approximately 15 minutes, including set-up and clean-up. You will be one of 20 study participants if you agree to be in this study.

Risks and Benefits of Participation

Risks: There are minimal risks if you participate in this study. Graston Technique is considered a manual therapy technique and may cause some bruising and/or soreness. These symptoms are considered normal and will not affect your athletic performance or daily function. The soreness and bruising that may be experienced with this study is comparable to a deep tissue massage. Ice and stretching may be applied on your own time in order to help alleviate any discomfort after the treatment session.

Benefits: This study will help researchers understand the effect of Graston Technique has on Chronic Ankle Instability in intercollegiate athletes.

Alternatives
There are no alternatives.

Possible Injury Statement
If you are hurt during this study, we will make sure you get the medical treatment you need for your injuries. However, the university will not pay for the medical treatment or repay you for
those expenses.

Volunteer Statement
You are a volunteer. The decision to participate in this study is completely up to you. If you decide to be in the study, you may stop at any time. You will not be treated any differently if you decide not to participate in the study or if you stop once you have started.

Confidentiality Statement
Any information about your participation, including your identity, is completely confidential. The following steps will be taken to ensure this confidentiality: You will be assigned a code number and all questionnaires and step logs will contain your number. The master sheet with your name and assigned number will be kept separate from the data locked in a filing cabinet in the investigators office. All data collection sheets will be stored in a locked filing cabinet in the Athletic Training Room (Judy W. Rose Football Center). Only the investigators will have access to your information.

Statement of Fair Treatment and Respect
UNC Charlotte wants to make sure that you are treated in a fair and respectful manner. Contact the university's Research Compliance Office (704-687-1871) or email at uncc-irb@uncc.edu if you have questions about how you are treated as a study participant. If you have any questions about the actual project or study, please contact Jeffrey Adam Jordan (704-687-1830, jajorda1@uncc.edu) or Dr. Tricia Hubbard Turner (704-687-6202, thubbar1@uncc.edu)

Approval Date

This form was approved for use on January 28, 2015 for use for one year.

Participant Consent

I have read the information in this consent form. I have had the chance to ask questions about this study, and those questions have been answered to my satisfaction. I am at least 18 years of age, and I agree to participate in this research project. I understand that I will receive a copy of this form after it has been signed by me and the principal investigator of this research study.

____________________________________ ______________________
Participant Name (PRINT) DATE

____
Participant Signature

____________________________________ ______________________
Investigator Signature DATE

APPENDIX B: FAAM AND FAAM SPORT SUBSCALE QUESTIONNAIRE

Foot and Ankle Ability Measure (FAAM)

Activities of Daily Living Subscale

Please Answer **<u>every question</u>** with **<u>one response</u>** 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	☐	☐	☐	☐	☐	☐
Walking on even Ground	☐	☐	☐	☐	☐	☐
Walking on even ground without shoes	☐	☐	☐	☐	☐	☐
Walking up hills	☐	☐	☐	☐	☐	☐
Walking down hills	☐	☐	☐	☐	☐	☐
Going up stairs	☐	☐	☐	☐	☐	☐
Going down stairs	☐	☐	☐	☐	☐	☐
Walking on uneven ground	☐	☐	☐	☐	☐	☐
Stepping up and down curbs	☐	☐	☐	☐	☐	☐
Squatting	☐	☐	☐	☐	☐	☐
Coming up on your toes	☐	☐	☐	☐	☐	☐
Walking initially	☐	☐	☐	☐	☐	☐
Walking 5 minutes or less	☐	☐	☐	☐	☐	☐
Walking approximately 10 minutes	☐	☐	☐	☐	☐	☐
Walking 15 minutes or Greater	☐	☐	☐	☐	☐	☐

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	Slight Difficulty	Moderate Difficulty	Extreme Difficulty	Unable to do at all	N/A
Home responsibilities	☐	☐	☐	☐	☐	☐
Activities of daily living	☐	☐	☐	☐	☐	☐
Personal care	☐	☐	☐	☐	☐	☐
Light to moderate work (standing, walking)	☐	☐	☐	☐	☐	☐
Heavy work (push/pulling, climbing, carrying)	☐	☐	☐	☐	☐	☐
Recreational activities	☐	☐	☐	☐	☐	☐

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	Slight Difficulty	Moderate Difficulty	Extreme Difficulty	Unable to do at all	N/A
Running						
Jumping						
Landing						
Starting and stopping quickly						
Cutting/lateral Movements						
Ability to perform Activity with your Normal technique						
Ability to participate In your desired sport As long as you like						

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 Abnorm

APPENDIX C: CUMBERLAND ANKLE INSTABILITY TOOL

Cumberland Ankle Instability Tool (CAIT)

Please tick the ONE statement in EACH question that BEST describes your ankles.

	LEFT	RIGHT
1. I have pain in my ankle		
Never	□	□
During sport	□	□
Running on uneven surfaces	□	□
Running on level surfaces	□	□
Walking on uneven surfaces	□	□
Walking on level surfaces	□	□
2. My ankle feels UNSTABLE		
Never	□	□
Sometimes during sport (not every time)	□	□
Frequently during sport (every time)	□	□
Sometimes during daily activity	□	□
Frequently during daily activity	□	□
3. When I make SHARP turns, my ankle feels UNSTABLE		
Never	□	□
Sometimes when running	□	□
Often when running	□	□
When walking	□	□
4. When going down the stairs, my ankle feels UNSTABLE		
Never	□	□
If I go fast	□	□
Occasionally	□	□
Always	□	□
5. My ankle feels UNSTABLE when standing on ONE leg		
Never	□	□
On the ball of my foot	□	□
With my foot flat	□	□
6. My ankle feels UNSTABLE when		
Never	□	□
I hop from side to side	□	□
I hop on the spot	□	□
When I jump	□	□
7. My ankle feels UNSTABLE when		
Never	□	□
I run on uneven surfaces	□	□
I jog on uneven surfaces	□	□
I walk on uneven surfaces	□	□
I walk on a flat surface	□	□
8. TYPICALLY, when I start to roll over (or "twist") on my ankle, I can stop it		
Immediately	□	□
Often	□	□
Sometimes	□	□
Never	□	□
I have never rolled over on my ankle	□	□

9. After a TYPICAL incident of my ankle rolling over, my ankle returns to "normal"

Almost immediately	□	□
Less than one day	□	□
1–2 days	□	□
More than 2 days	□	□
I have never rolled over on my ankle	□	□

APPENDIX D: BALANCE ERROR SCORING SYSTEM (BESS) FORM

The Balance Error Scoring System (BESS)

Obtain Preseason Baseline Score; Compare with Post-Concussion Score[33-34]

The Balance Error Scoring System[33-34] provides a portable, cost-effective and objective method of assessing static **postural stability**. The BESS can be used to assess the effects of mild head injury on static postural stability. Information obtained from this clinical balance tool can be used to assist clinicians in making return to play decisions following mild head injury. The BESS can be performed in nearly any environment and takes approximately 10 minutes to conduct.

The balance-testing regime consists three stances on two different surfaces. The three stances are **double leg stance**, **single leg stance** and **tandem stance**. The two different surfaces include both a **firm** (ground) and **foam** surface. **Athletes' stance should consist of the hands on the iliac crests, eyes closed and a consistent foot position depending on the stance**. Shoes should not be worn.

In the **double leg stance**, the feet are flat on the testing surface approximately pelvic width apart.

In the **single leg stance** position, the athlete is to stand on the non-dominant leg with the contralateral limb held in approximately 20° of hip flexion, 45° of knee flexion and neutral position in the frontal plane.

In the **tandem stance** testing position, one foot is placed in front of the other with heel of the anterior foot touching the toe of the posterior foot. The athlete's non-dominant leg is in the posterior position. Leg dominance should be determined by the athlete's kicking preference.

Administering the BESS: Establish baseline score prior to the start of the athletic season. After a concussive injury, re-assess the athlete and compare to baseline score. Only consider return to activity if scores are comparable to baseline score. Use with Standardized Symptom Scale Checklist.

Scoring the BESS: Each of the trials is **20 seconds.** Count the number of errors (deviations) from the proper stance. The examiner should begin counting errors only after the individual has assumed the proper testing position.

Double Leg Stance Firm Surface | Single Leg Stance Firm Surface | Tandem Stance Firm Surface | Double Leg Stance Foam Surface | Single Leg Stance Foam Surface | Tandem Stance Foam Surface

Errors:
- **Moving the hands off the hips**
- **Opening the eyes**
- **Step, stumble or fall**
- **Abduction or flexion of the hip beyond 30°**
- **Lifting the forefoot or heel off of the testing surface**
- **Remaining out of the proper testing position for greater than 5 seconds**

The maximum total number of errors for any single condition is 10.

If a subject commits multiple errors simultaneously, only one error is recorded.

B.E.S.S. SCORECARD

Count Number of Errors max of 10 each stance/surface	FIRM Surface	FOAM Surface
Double Leg Stance (feet together)		
Single Leg Stance (non-dominant foot)		
Tandem Stance (non-dominant foot in back)		
TOTAL SCORES: total each column		
B.E.S.S. TOTAL: (Firm+Foam total)		

Airex™ Foam Balance Pads available at **www.power-systems.com** or through most sporting goods stores.

APPENDIX E: DATA COLLECTION CHART

DUPERSID	GENDER	AGE	HEIGHT	WEIGHT	INVOLVED LIMB	SPORT	FAAM %	FAAM%(Post 4)

DUPERSID	FAAM%(Post 2)	FAAM	FAAM Post 4 Weeks	FAAM Post 2 Weeks	FAAMS %	FAAMS% (Post4)

DUPERSID	FAAMS%(Post2)	FAAM SPORT	FAAM SPORT (Post 4)	FAAM SPORT (Post 2)	Monofilament	Monofilament Post 4 Weeks

DUPERSID	Monofilament Post 2 Weeks	Lunge	Lunge (Post 4)	Lunge (Post 2)	BESS	BESS Post 4 Weeks	BESS Post 2 Weeks

DUPERSID	Anterior Drawer	Anterier (Post4)	Anterior (Post2)	Talar Tilt	Talar (Post4)	Talar (Post2)	Total # of Sprains