EFFECTS OF A SINGLE-SESSION GRASTON TECHNIQUE ON HAMSTRING FLEXIBILITY AND MUSCLE STIFFNESS OF RECREATIONALLY ACTIVE INDIVIDUALS

By

NATHAN J. HOFFMEIER

Bachelor of Science in Athletic Training

Ball State University

Muncie, IN

2011

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2014

EFFECTS OF A SINGLE-SESSION GRASTON

TECHNIQUE ON HAMSTRING FLEXIBILTY AND

MUSCLE STIFFNESS OF RECREATIONALLY

ACTIVE INDIVIDUALS

Thesis Approved:

Dr. Jennifer Volberding

Thesis Adviser

Dr. Aric Warren

Dr. Matthew O'Brien

ACKNOWLEDGEMENTS

I would like to first thank the Oklahoma State University Athletic Training Education Program and all of the students who volunteered their time to participate in this study throughout the course of the past two semesters. Without them I would have had limited opportunities to recruit subjects and make all of this possible in my final year as a graduate student. Also to all of the professors and other individuals who assisted me throughout the entire process from start to finish and never lost faith that I would complete this goal; Dr. Jennifer Volberding for helping me set my deadlines and assuring that I was always staying on task, Dr. Aric Warren for assisting me with all of my Graston Technique data collection, and Ty Palmer for assisting with the development of the methodology and statistical analysis.

Also, I would like to thank each and every one of my fellow Graduate Assistants and friends both past and present for being an outstanding support system during this entire process. Making the decision to return for a third year was the greatest thing I could have done. It has provided me the opportunity to build even more life-long friendships with those of you here. Finally to Todd Gerlt for taking the chance to allow me this amazing opportunity sight unseen. It has been a roller coaster journey, but the support and guidance you have provided has made me a better person and clinician to this day.

Name: NATHAN J. HOFFMEIER, ATC/LAT

Date of Degree: MAY 2014

Title of Study: EFFECTS OF A SINGLE-SESSION GRASTON TECHNIQUE ON HAMSTRING FLEXIBILTY AND MUSCLE STIFFNESS OF RECREATIONALLY ACTIVE INDIVIDUALS

Major Field: HEALTH & HUMAN PERFORMANCE - APPLIED EXERCISE SCIENCE

Abstract: This study is an attempt to provide support for the clinical use of a single session Graston Technique intervention to improve flexibility and decrease musculotendinous stiffness (MTS). Thirty subjects were recruited to participate in the study from the Oklahoma State University Athletic Training Education Program and related Master's programs. Subjects were randomly divided into two groups and completed either a Graston Technique (n=17) or Control (n=12) intervention and were passively stretched to their maximum range of motion (ROM) seven times (pre-intervention, post-intervention, 10-, 20-, & 30- minutes post-intervention, as well as 48-, & 72- post-intervention) using a Biodex Isokinetic Dynamometer to assess for MTS, passive torque, and maximum ROM. Due to corrupt data of one subject's files, only twenty-nine of the subjects were analyzed. Only the first six time points were analyzed due to subjects being unable to complete data collection of the 72hr time point. Results for MTS presented only a main-effect for joint-angle, implying that as with previous literature MTS increased as joint angle increased. Statistical analysis for flexibility presented that maximum ROM was greater at 30 minutes post-intervention than pre-intervention ($p \leq 0.001$), post-intervention ($p \leq 0.001$), and 10-minutes post-intervention ($p = 0.002$). However, subjects gravitated towards baseline @ 48-hours post-intervention. Results of this study suggest that a single-session GT intervention would present no significant short-term or long-term effects on MTS of flexibility.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

In the world of Athletic Training today, different methods of soft tissue mobilization are becoming increasingly prevalent in the treatment of musculoskeletal injuries. A number of studies have already shown that passive stretching alone can be an effective method of increasing flexibility and range of motion (ROM). However, as the Athletic Training profession evolves and new methods of achieving increased flexibility and ROM are implemented, we often question their effectiveness. That is where evaluating the long-term effectiveness of soft tissue mobilization methods, such as the Graston Technique® comes in to question.

Among these methods of soft tissue mobilization is a specific group of skills known as Augmented Soft Tissue Mobilization (ASTM) or Instrument Assisted Soft Tissue Mobilization (IASTM). These techniques include different methods of using deep tissue massage-like instruments to help restore joint motion, decrease muscle stiffness, eliminate myofascial adhesions and expedite the healing process of musculoskeletal injuries.

In regards to IASTM, a number of manual therapy techniques and their levels of effectiveness have been reviewed through individual account case studies. In a study evaluating the effectiveness of two different soft tissue mobilization techniques, Active Release Technique (ART) and The Graston Technique (GT), it was shown that both techniques may help increase hamstring flexibility. The authors found that subjects treated with the GT had increased hamstring flexibility, though the results were not significantly greater than ART.[1]

Kmieck's research is one of very few controlled studies that has been conducted on the GT. A vast majority of the current research lies within case studies that focus more on the GT as a part of an overall rehabilitation protocol, as opposed to examining solely the effects of GT as its own intervention. [3,4,5,6,7,8] Therefore further need for research would need to be conducted to further determine the effectiveness of GT on increasing hamstring flexibility. This study will aim to evaluate the long-term effects of a single-session GT intervention on increasing hamstring flexibility and musculotendinous stiffness (MTS) in apparently healthy college-aged students over the course of a 72-hour time period.

Hypothesis

1) An increase in hamstring flexibility will occur within the Graston Technique® group that is significantly greater than that of the control group immediately following treatment.
2) An increase in hamstring flexibility will occur within the Graston Technique® group that is significantly greater than that of the control group 10 minutes post treatment
3) An increase in hamstring flexibility will occur within the Graston Technique® group that is significantly greater than that of the control group 20 minute post treatment.

4) An increase in hamstring flexibility will occur within the Graston Technique® group that is significantly greater than that of the control group 30 minutes post treatment.
5) The Graston Technique® group will exhibit a decrease in hamstring MTS that is significantly greater than that of the control group immediately following treatment.
6) The Graston Technique® group will exhibit a decrease in hamstring MTS that is significantly greater than that of the control group 10 minutes post treatment.
7) The Graston Technique® group will exhibit a decrease in hamstring MTS that is significantly greater than that of the control group 20 minutes post treatment.
8) The Graston Technique® group will exhibit a decrease in hamstring MTS that is significantly greater than that of the control group 30 minutes post treatment.
9) The control group will have no significant change in flexibility or MTS immediately following their participation.
10) A single session Graston Technique® intervention will not exhibit significant long-term decreases in hamstring MTS and increased hamstring flexibility over the course of 48 hours.
11) A single session Graston Technique® intervention will not exhibit significant long-term decreases in hamstring MTS and increased hamstring flexibility over the course of 72 hours.

Delimitations

1) College-aged students, both men & women, between the ages of 18 and 24 years old
2) Subjects must not compete in any form of competitive sports.
3) Recruited subjects must be free of injury to their hip, knee, or hamstring in the past 6 months.

Assumptions

Theoretical Assumptions

1. All subjects will provide accurate information on the health history questionnaire
2. All subjects will provide honest descriptions of their comfort levels
3. All subjects will give a maximum effort throughout the study.
4. Application of Graston Technique will be consistent throughout all subjects' treatment session.
5. The Biodex Isokinetic Dynamometer used to assess hamstring flexibility and muscle stiffness will provide an accurate and reliable method for collecting data.

Statistical Assumptions

1. The population from which subjects are recruited is normally distributed
2. Homogeneity of variance is present among samples.
3. Results of all groups are independent of other groups.
4. Statistical data is on a parametric scale.

Limitations

The limitations of this study are that subjects will be recruited primarily from the students of the Oklahoma State University Athletic Training Education Program and related Master's programs through verbal communication and classroom invitations. Also, this population will not allow for the possibility to observe the effects and potential changes in muscle flexibility and stiffness of an athletic population to which these techniques are typically applied.

CHAPTER II

REVIEW OF LITERATURE

Soft Tissue Mobilization

Numerous methods of soft-tissue mobilization are currently used in the treatment of different musculoskeletal conditions.[20] These methods include the likes of massage, Active Release Technique (ART), Gau Sha, and other Augmented Soft Tissue Mobilization methods (ASTM). Soft-Tissue Mobilization methods such as ART involves taking the muscle from a shortened position to a lengthened position while a clinician utilizes a hands-on method to create a longitudinal tension along the affected muscle.[22] The classification known as ASTM or Instrument Assisted Soft Tissue Mobilization (IASTM) includes the use of instrumentation to provide the mobilization of soft tissue with methods such as The Graston Technique (GT) or Sound Assisted Soft Tissue Mobilization (SASTM). [9,10,11,12]

Historically with frictional massage, multiple sources have supported the principles soft tissue mobilization including reduction of scar tissue, augmenting the inflammatory process, and restoring free motion of soft tissue by removing adhesions[2, 3]. However, recent advances in soft tissue mobilization methods including ART and ASTM/IASTM have been supported for their effectiveness in treating tendinopathies[4], epicondylopathies[5], muscle strains[6], and other orthopedic musculoskeletal conditions[3]. Previous literature on these techniques typically consisted of case studies in which soft tissue mobilization techniques were not the sole treatment of the musculoskeletal condition. [3,4,5,6]. A common theme amongst the previously mentioned case studies and other ASTM/IASTM related research is that they often include a combination of modality interventions with therapeutic exercise[5], other methods of soft tissue mobilization[2], or a combination of the three[6].

In two different cases, both Papa[4] and Miners et al.[7] found that when combined with other modality interventions that ASTM/IASTM was an effective treatment for Achilles tendinopathies[4, 7]. Papa found that with incorporating ASTM/IASTM into the rehabilitation protocol of a 77-year-old female with chronic Achilles tendinopathy, after 12 treatment sessions her pain had been completely resolved and the patient had become significantly more functional in regards to her lower extremity. The patients also presented long-term resolve as a result of the intervention, as she reported no symptoms upon a one-year follow-up phone call.[4] Miners et al. found that combining both ART and ASTM in the form of GT into the rehabilitation protocol of a 40-year old physically active male with chronic bilateral Achilles tendinopathy was able to resolve pain and return the patient to their pre-injury state after 9 in-office sessions and a home rehabilitative program.[7]

Other cases utilizing soft tissue mobilization and rehabilitation have become an effective combination for the treatment of epicondylopathies.[5, 8] Howitt[8] found that by incorporating the ART method of soft tissue mobilization along with a therapeutic exercise and local modality prescription, significant improvements could be accomplished in the treatment of lateral epicondylosis. Over the course of two weeks, a 51-year old tennis player received six ART and therapeutic exercise interventions. The ART was focused at the origin of the wrist extensors, while the rehabilitation focused generally on stretching the muscles of elbow, wrist, and shoulder. The strengthening focus of the rehabilitation program focused on the muscles of the wrist. The patient claimed an 80% improvement in symptoms following only one session and noticed complete, long-standing resolve at the time of discharge and up to two-months post treatment[7]. Papa[5] combined GT, acupuncture, electrical stimulation, and a therapeutic exercise protocol for the treatment of two separate cases of lateral epicondylopathy. While the cases differed in that one patient was restricted from inflammation-causing work related duties and the other continued work related duties with the assistance of a counter-force brace. Both patients saw complete resolution of their symptoms following a total of 10 and 12 treatment sessions respectively.

In addition to epicondylopathies and tendinopathies, ART and ASTM (GT) have been found to be effective compliments in the rehabilitation of muscle strains and friction syndromes, specifically the tibialis posterior muscle and the Illiotibial band (ITB) respectively. Howitt et al[6] found that utilizing the ART and GT in combination with acupuncture and therapeutic exercise was effective in the treatment of a tibialis posterior muscle strain and ITB friction syndrome.[6] A 41-year old novice male triathlete was first treated for a distal ITB friction syndrome utilizing ART, GT, acupuncture, and therapeutic exercise with a reported near 100% resolution at the time the patient reported the posterior tibilias strain 3 months later. The patient was then treated at the ankle with similar methods in ART, GT, Acupuncture, and therapeutic exercise. The patient reported complete resolution of his symptoms that were confirmed at a one-month symptom free follow-up.[6]

While it is made apparent from previous case studies that soft tissue mobilization can be effective in combination with therapeutic exercise and/or other therapeutic modalities, further research should be conducted on whether or not soft tissue mobilization alone is effective in achieving the same treatment outcomes as the combined rehabilitation protocols. Along with that, it should be noted that these previous studies have included numerous treatment sessions of soft tissue mobilization. [3,4,5,6,7,8] While one case reported that a patient saw an 80% improvement after the first session[7], future research should strive to confirm the long-term effects of these ASTM and other soft tissue mobilization methods after a single intervention. This study will examine specifically the GT method of ASTM to determine it's long-term effectiveness on hamstring flexibility and muscle stiffness. However, first a review of how the GT is to be applied, the recommended treatment dosages, and how effective this method alone has been in the treatment of related orthopedic and musculoskeletal conditions.

Graston Technique

The GT is has been shown to be an effective supplement in the treatment of numerous musculoskeletal orthopedic conditions such as muscle strains, tendinopathies, and epicondylopathies. However, knowing that it is an effective supplement to rehabilitation protocols provides no indication that it would be of benefit when used in isolation. Therefore an understanding of treatment frequency, duration, and methodology for the use of GT should be established. This section will describe the contemporary way to apply the GT, as well as treatment parameters such as duration and frequency. Based on information, the current study will attempt to increase the general knowledge and understanding of the GT by evaluating these factors that have not been researched in this manner.

First researched at Ball State University in Muncie, IN the GT has become an increasingly popular method of ASTM/IASTM, as it is currently included in the regular academic curriculum of at least 57 colleges and universities and used by almost 17,000 athletic trainers, chiropractors and therapists around the world.[10] Howitt et al[3] and Stow[9] describe the GT as stainless steel tools, designed with either single-beveled or double-beveled edges, specifically for the release of scar tissue, Myofascial adhesions and restrictions. These instruments are then moved across the skin in a multidirectional, massage-like, stroking motion at a 30°-60° angle.[3] According to Melham et al[11], at the beginning of the application, the massage like strokes are to be long and flowing. As the instruments are moved across the skin, the clinician will be able to identify myofascial adhesions by a noticeable vibration within the instrument as it is moved across the affected area indicating possible scar or tissue lesion. Once the affected area has been detected the strokes are to gradually become more local and instruments with smaller surface area are to be used to increase pressure to the area and theoretically better mobilize the tissue. This process is then carried out over the course of 5-10 minutes.[11]

The frequency and total number of recommended GT intervention sessions seem to vary based on the condition being treated as noted by the previously mentioned literature. Even among case studies that contain treatments of similar conditions, the number of treatments varied. Two case studies that examined the treatment of Achilles tendinopathies exhibited this trend[4,7]. The first case presented a treatment plan in which GT was applied a total of 4 times. The patient was treated with GT twice a week for the first 2 weeks of an 8-week treatment plan.[4] The second case involving Achilles tendinopathies saw the patient treated twice a week for three weeks followed by a single session every 7-10 days, for a total of 9 treatment sessions.[7] In 2 other cases, the treatment frequency and number a sessions once again varied in the treatment of epicondylopathies.[5] Within the two cases, patient 1 was seen once a week for 2 weeks followed by once a week sessions for 6 weeks for a total of 10 GT treatments. While patient 2 was treated twice a week for three weeks followed by once a week for 6 weeks for a total of 12 GT treatments. Throughout all of these cases, the patients experienced complete and long-standing resolution of their symptoms.[4,5,7] The varied number of treatment sessions could suggest that there may not be a specific standard for the number of treatment sessions needed to observe significant improvements. Having a general understanding of the physiological affects along with future research to determine the effectiveness of each session should allow for better guidelines in the future.

While a majority of the literature involving GT research is comprised of case studies in which it is combined with other methods of soft tissue mobilization to supplement its effectiveness there have been animal-model studies that help to support the physiological benefits of the GT alone. A study examining the morphological and functional changes in the tendons of male Sprague-Dawley rats, investigators used light and electron microscopy to determine the physiological effects of ASTM/IASTM on the Achilles tendon. Following microscopic examination, it was observed that ASTM/IASTM may promote healing of the tendon through the activation of healing cells known as fibroblasts which serve as the foundation cells in which soft tissue is built. Within two of the treatment groups, an increased number of fibroblasts were observed which supports the idea that ASTM/IASTM may augment the healing process, as an increase in fibroblasts is one of the initials steps of the healing process.[2] In another study, Gehlsen[13] also examined the morphological changes in the Achilles tendons of Sprague-Dawley rats under different variations of ASTM/IASTM pressure following a chemically induced tendonitis. After being divided into 5 treatment groups, the "tendonitis plus extreme ASTM/IASTM" group exhibited a significant difference in fibroblast recruitment. Once again promoting the use of ASTM/IASTM for tissue healing. A third study, also using Sprague-Dawley rats examined the effects of Instrument Assisted Cross Fiber Massage (IACFM) for the treatment of a surgically induced MCL injury. The cross fiber massage was performed using the GT and was initialized at one week post-surgery. Once again, microscopic evaluation results were used to determine the tissue results. At 12 weeks post-injury, there was minimal to no difference between treated and untreated ligaments. The author proposed that this supports an idea that IACFM may accelerate the early-stages of healing, but has a minimal effect on augmentation of the healing process. [13]

As the tissue begins to heal following an injury, clinicians begin to set their rehabilitation goals such as restoring functional joint range of motion and appropriate muscle flexibility to the affected area before beginning a substantial amount of strengthening exercises. The GT has been previously noted to reduce scar tissue, alleviate myofascial restrictions, allow for normal movement of the tissue[3, 9], as well as augment and promote soft tissue healing[2, 13]. It has been hypothesized that possible benefits of reducing the scar tissue and allowing for free movement of the tissue are an increase in joint range of motion, muscle flexibility, and decreases in MTS. In the case of a 20-year old football player with chronic right ankle pain, decreased range of motion, and dysfunctional scar tissue Melham et al[11] found that GT, when applied in combination with other therapeutic exercises and modalities can be an effective way to increase joint range of motion and flexibility. The patient was treated twice a week for 7 weeks for a total of 14 treatments. At the conclusion of the treatment, the patient exhibited joint range of motion increases in plantarflexion, inversion, eversion, and dorsiflexion motions, as well as an 18° increase in Soleus muscle flexibility.[11] While this case provides a clinical insight into the benefits of GT in regards to this study, a better understanding of muscle flexibility and MTS should be developed to allow future research such as this to focus directly on the effects of GT in relation to muscle flexibility and MTS.

Hamstring Flexibility & Musculotendinous Stiffness

Hamstring muscle flexibility, MTS and its relationship to performance and injury rate has long been a topic of discussion for many athletic related health care professionals such as Athletic Trainers and Physical Therapists. Gleim and McHugh[14] note that flexibility can be divided into either static or dynamic categories. They defined static flexibility as the available range of motion (ROM) at a singe joint or combination of joints, while dynamic flexibility is the ease at which a muscle can move within a certain ROM. MTS, expressed as the tissues resistance against deformation is a key component of dynamic flexibility.[14] Currently we are unaware of any research exclusively investigating the direct effects of the GT increasing hamstring flexibility and decreasing MTS. However, other methods of increasing flexibility and decreasing stiffness have been researched for their correlation between flexibility, injury rates, and performance especially at the musculo-tendinous junction (MTJ) where the muscle itself connects to the tendon.[12,13,14,15]

Safran et al.[15] examined the effectiveness of pre-conditioning or "warming-up" to increase flexibility and decrease stiffness of the Flexor Digitorum Longus (FDL), Extensors Digitorum Longus (EDL), and Tibialis Anterior (TA) of rabbits. To pre-condition the muscle, the motor nerve was electrically stimulated for an average of 15 seconds or until the muscles maximal isometric force was generated. It was found that depending on the muscle, between 4-9% more force was required to cause a lesion of the isometrically pre-conditioned muscles when compared to their non-conditioned controls. Also, a statistically greater length was required to tear each of the muscles tested. Regardless of pre-conditioning, it was found that all muscle tears occurred at the same MTJ as their controls. [15] Safran et al[15] reported that the benefits of pre-conditioning are a possible result of stretching the muscle to allow for an increased length as it exposed to a force, therefore placing less tension on the MTJ and reducing the risk of injury.

In another study focusing on the implementation of a static stretching program to reduce musculotendinous strains, Cross and Worrell found a marked reduction in injury incident from year to year amongst 195 collegiate football players. Although the practice schedule remained the same, a static stretching program was implemented in which athletes were asked to hold stretches for a period of 15 seconds and repeat them 3 times bilaterally prior to conditioning activities. When a retrospective review of medical records was completed it was found that there was a 48% reduction in the number of musculotendinous strains.[16] While it has been discussed that pre-conditioning and pre-activity static stretching can help prevent muscle and musculotendinous strain, other studies have debated as to whether or not pre-conditioning and/or pre-activity stretching immediately prior to activity can in fact prevent injury and increase performance. Although a regular stretching program at other times is still advocated.[17] With a general understanding as to whether or not increased flexibility and decreased MTS improves performance or reduce injury, methods of assessing these components have been long studied as well. [18, 19]

Biodex Measurement Efficacy

As flexibility and MTS should still be considered key components of injury prevention and performance enhancement, reliable methods of quantifying these components should also be examined. Numerous authors have studied the reliability of both manual and automated methods to assess passive hamstring flexibility and MTS.[18,19] Palmer et al[18] stated that the use of an automated isokinetic dynamometer is the most common method of measuring passive flexibility and MTS. However a clinical shortcoming is that measurements must be taken in a laboratory setting due to the fact that they are large, often immobile, pieces of equipment. Following their study, Palmer et al[18] found that within a small sample size, when comparing a manual technique using an electrogoniometer and passive movement by the investigator and an automated technique using the Biodex System 3, these methods were reliable for assessing flexibility and MTS of the posterior hip and thigh.[18]

The use of a Biodex System 3 isokinetic dynamometer provided a reliable method in which to assess flexibility and MTS when collecting laboratory data.[18] Related studies have utilized similar methods and instrumentation as well to help support the use of isokinetic dynamometers for the collection of flexibility and MTS data.[19] Other studies used similar instrumentation to examine the effects of passive stretching on hamstring extensibility and passive stiffness as well. Marshall et al.[19] reported that the use of isokinetic dynamometers to perform instrument assisted straight leg raises (iSLR) was a reliable and easy method to reproduce for measuring hamstring flexibility and MTS as illustrated by their use of the KinCom isokinetic dynamometer to collect data on twenty-two recreationally active individuals following bouts of passive stretching.[19]

Summary

Following a broad review of the literature it was determined that minimal research has been conducted solely on the effects of GT. As previously stated, the majority of literature relating to GT exists in the form of case studies which researchers have implemented the use of GT as only a part of their protocol. Although the mentioned case studies saw positive treatment results when incorporating GT with modalities, therapeutic exercise, and/or other methods of soft tissue mobilization. The results mostly related to restoring ROM, reducing pain, and increasing flexibility. It was also noted that within the case studies that GT interventions occurred numerous times throughout the course of the researchers protocol. [3,4,5,6,7] To our current knowledge, no research has been conducted on the effects of GT when performed as the lone intervention within a treatment protocol. This study will serve to examine the effects of a single-session GT intervention on hamstring MTS and flexibility.

CHAPTER III

METHODOLOGY

Subjects:

Thirty college-aged students between the ages of 18-24 were recruited through classroom presentations within the Oklahoma State University Athletic Training Education Program and Related Master's Degree Program courses for this study. The Oklahoma State University Institutional Review Board for research involving Human Subjects approved this study. All subjects were required to complete a health history question and sign an informed consent form prior to participation in the study. To be eligible for this study subjects must have been free of any hip, knee, or hamstring injury for six months prior to the study. Also, subjects had to be willing to undergo one session of the Graston Technique® soft tissue mobilization. Each subject was explained the risks involved with participation, including a short video demonstration, prior to their consent to participate in the study. All subjects were required to complete an informed consent form before health history questionnaires were accepted or any data collection was completed.

Research Design

The thirty recruited subjects were randomly divided into two groups of fifteen participants. One group of fifteen received a five minute single session of the Graston Technique® applied in a sweeping and fanning stroke to the right hamstring. The remaining group of fifteen subjects served as the control group by remaining seated comfortably for five minutes while receiving no treatment. All participants reported to the Oklahoma State University Applied Musculoskeletal and Human Physiology Research Laboratory on four separate occasions. During their initial visit, all subjects were asked to complete their health history questionnaire & sign their informed consent form. Once completed, if eligible for inclusion in the study, subjects were introduced to the Graston Technique® as well as the stretching technique that was utilized within the study to obtain flexibility and MTS data. Upon the subject's second visit, they underwent pre-treatment hamstring flexibility and MTS measurements, were randomly assigned to the treatment or control group, completed their treatment assignment, and received their first set of post-intervention hamstring flexibility and MTS measurements at 0, 10, 20, and 30 minutes post-intervention. The third testing session occurred 48 hours post-intervention during which time, hamstring flexibility and MTS was measured one time. The fourth and final testing session for each subject occurred 72 hours post-intervention during which time, hamstring flexibility and MTS were measured one time.

Variables

The independent variable in this study was the type of treatment (Graston Technique® or control). The dependent variables in this study were MTS, passive torque (PT) and maximum range of motion (ROM).

<u>Instrumentation</u>

- Graston Technique® Instruments (Fig. I), specifically GT1 (Fig. II) (Graston Technique; Indianapolis, IN) was used to apply Graston technique® protocol to the right hamstring of subjects in the Graston Technique® group.

FIGURE I

FIGURE II

- Graston Technique® Soft Tissue Mobilization Emollient (Graston Technique®; Indianapolis, IN) was applied to the subjects receiving the Graston Technique® treatment.
- BIODEX System 4 Pro Isokinetic Dynamometer (BIODEX Medical Systems; Shirley, NY) combined with a straight-leg immobilizer, and customized ankle immobilizer were used to assess hamstring flexibility by measuring amount of maximal hip flexion achieved pre- and post- treatment intervention as seen in figure III & IV.

FIGURE III

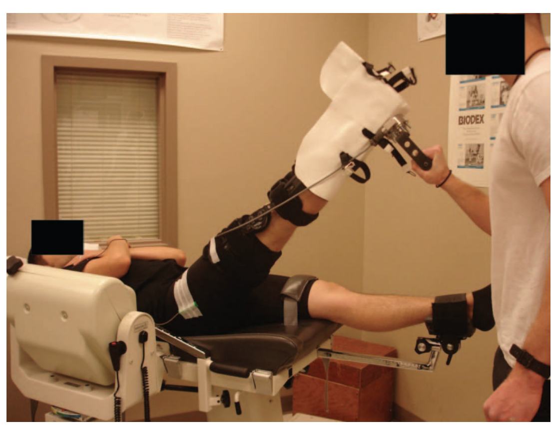

FIGURE IV: Palmer et al.[18]

Familiarization Protocol

During the initial visit, subjects all participated in a familiarization session. The subject was be provided a 1-minute treatment to the left hamstring using Graston Technique® Instrument GT 1, at the end of the 1-minute treatment, each subject was undergo a hamstring stretch similar to that of the one included in the study. The subject will be lying in a supine position with the knee and ankle in immobilization devices. With the lower-extremity splinted, the Biodex lever was then slowly raise the leg in a manner similar to that of a typical hamstring stretch for a total of 15-30 seconds. The stretch continued until the maximum tolerated range of motion was reached. At that time, the end point ROM was recorded and the subject was slowly returned to their original resting position.

Measurement Protocol

During the subjects second visit they underwent both pre- and post- intervention measurements of hamstring flexibility and MTS. During the third and fourth visits a single measure of hamstring flexibility and MTS were taken. In order to assess these variables, the subjects were placed in a supine position with their right lower extremity placed into knee and ankle immobilizers. Once the knee and ankle were in the immobilizers, the Biodex lever then raised the lower extremity at a slow computer-controlled rate for 15-30 seconds. The stretch was then taken to the subjects maximum tolerated range of motion. A total of five stretches occurred during the second session. A single hamstring flexibility and MTS measurement was taken during each of the third and fourth sessions.

Graston Protocol

Subjects in the Graston Technique® group received a 5-minute Graston Technique® treatment using instrument GT1 to the right hamstring muscle group. With the subject lying in a prone position, the right hamstring muscle group exposed, Graston Technique® Soft Tissue Mobilization Emollient was lightly applied over the skin, followed by the utilization of Graston Technique® Instrument GT1 in a sweeping stroke for duration of 5-minutes on the hamstring muscle group of the right leg. The strokes were applied to the entire length of posterior thigh at a consistent rate. Strokes were applied in a distal to proximal direction at a rate of 30 strokes per minute for one minute, followed by 30 strokes per minute for one minute in a proximal to distal direction. This sequence repeated for two more minutes. The final minute consisted of 15 strokes in each direction. Throughout the duration of the study all Graston interventions were performed by the same certified clinician to ensure reliability between subjects.

Statistical Analysis

A 3-way mixed factorial ANOVA (time [pre-intervention versus post-intervention versus 10 minutes versus 20 minutes versus 30 minutes versus 48 hours] x intervention [control versus GT] x angle [angle 1 versus angle 2 versus angle 3 versus angle 4]) was used to analyze passive torque and MTS data. A 2-way mixed factorial ANOVA (time [pre-intervention versus post-intervention versus 10 minutes versus 20 minutes versus 30 minutes versus 48 hours] x intervention [control versus GT]) was used to analyze maximum ROM data. When appropriate follow-up analysis were conducted using lower-order ANOVAs and t-tests with Bonferroni corrections. An alpha of $P < .05$ was used to determine statistical significance. No 72- hour post intervention data was analyzed due to insufficient subject numbers. Statistical analyses were performed using SPSS Version 21.0.

CHAPTER IV

RESULTS

After all data was collected and organized, it was analyzed to determine if a single session of GT IASTM will decrease MTS and increase flexibility of the hamstring muscles. The demographical statistics including means (standard deviation) for height (cm), mass (kg), and thigh circumference (cm) of the participants can be found in Table I. The descriptive statistics for PT and MTS are displayed in Table II. Table III contains the descriptive statistics for the maximum ROM across all six available time-points.

TABLE I: Descriptive Statistics for the demographics of all study participants.

	NUMBER OF SUBJECTS:	n = 17	n = 12
	INTERVENTION:	**Graston**	**Control**
Demographics		Mean (SD)	Mean (SD)
	Height (cm)	167. 19 (9.9)	170.82 (9.9)
	Mass (kg)	69.48 (14.6)	80.32 (16.1)
	Thigh Circumference (cm)	49.8 (5.1)	51.27 (5.4)

<u>Musculotendinous Stiffness</u>

When the data was analyzed for GT's effects on MTS, it was found that the ANOVA indicated that there was no 3-way interaction (F = 2.049; p = 0.102), no 2-way interaction (F = .256- 2.432; p = 0.060- 0.636), but there was a significant main effect for both time (F = 4.237; p = 0.046) and joint angle (F = 52.051; $p = \leq 0.001$). The main effect for joint angle indicated that as joint angle increased, MTS also increased across all 4 joint angles (1<2<3<4). The main effect for time was also observed, however a more in depth analysis of the pair-wise comparisons indicated no significant difference across the 6 time points.

TABLE II: Descriptive Statistics for all Musculotendinous Stiffness data

			Joint Angle 1	Joint Angle 2	Joint Angle 3	Joint Angle 4
			Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
Passive Stiffness	Pre-Intervention	Graston	1.60 (2.3)	1.73 (2.3)	1.86 (2.3)	1.99 (2.3)
		Control	1.27 (1.6)	1.38 (1.7)	1.62 (1.8)	1.88 (1.9)
	Post-Intervention	Graston	1.6 (2.3)	1.76 (2.3)	1.93 (2.3)	2.10 (2.4)
		Control	1.12 (1.5)	1.35 (1.6)	1.60 (1.7)	1.88 (1.8)
	10- Min Post	Graston	1.60 (2.3)	1.75 (2.3)	1.90 (2.3)	2.05 (2.3)
		Control	1.15 (1.6)	1.36 (1.6)	1.61 (1.6)	1.89 (1.6)
	20- Min Post	Graston	1.57 (2.2)	1.74 (2.2)	1.92 (2.2)	2.12 (2.2)
		Control	1.21 (1.5)	1.44 (1.6)	1.69 (1.7)	1.98 (1.8)
	30- Min Post	Graston	1.59 (2.2)	1.74 (2.2)	1.88 (2.3)	2.03 (2.3)
		Control	1.17 (1.5)	1.38 (1.6)	1.61 (1.6)	1.85 (1.6)
	48- Hour Post	Graston	.61 (.7)	.75 (.8)	.90 (.9)	1.07 (1.1)
		Control	.74 (.6)	.87 (.7)	.97 (.8)	1.05 (1.1)

Passive Torque

In regards to PT, the ANOVA indicated no significant 3-way interaction (F= .297; p = 0.628) and no 2-way interaction for joint angle x intervention (F = .161; p = 0.692). There was a significant 2-way interaction between time x joint angle (F = 4.462; p =0.037). However, upon further analysis no significant interaction was observed for any pairwise comparisons for the 6 time points at all 4 joint angles, but passive torque did increase with joint angle for all 6 times points.

TABLE III: Descriptive Statistics for all Passive Torque data

			Joint Angle 1	Joint Angle 2	Joint Angle 3	Joint Angle 4
			Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)
Passive Torque	Pre-Intervention	Graston	80.74 (113.3)	89.26 (124.5)	98.59 (136.1)	108.29 (147)
		Control	50.28 (54.1)	56.54 (62.3)	63.72 (71)	72.49 (79.6)
	Post-Intervention	Graston	78.14 (112.2)	86.86 (123.2)	96.37 (134.85)	106.26 (146.1)
		Control	49.62 (54.2)	55.85 (61.4)	63.9 (69.6)	72.15 (78.4)
	10- Min Post	Graston	79.7 (112.6)	87.05 (124)	96.44 (135.8)	106. 48 (147)
		Control	50.95 (54.8)	57.4 (63.4)	65.20 (72.2)	73.02 (79.46)
	20- Min Post	Graston	79.04 (113.3)	87.46 (124.2)	96.46 (134.65)	106.38 (145.5)
		Control	52.37 (54.1)	58.59 (62.2)	66.31 (70.0)	75.93 (78.4)
	30- Min Post	Graston	78.09 (112.05)	86.68 (123.9)	96.00 (135.2)	105.61 (146.1)
		Control	51.62 (54.4)	57.51 (61.8)	65.07 (70.0)	73.95 (78.8)
	48- Hour Post	Graston	29.02 (23.5)	32.97 (28.1)	36.68 (31.7)	41.15 (35.0)
		Control	37.09 (16.4)	40.45 (18.7)	45.01 (21.5)	50.06 (25.2)

Maximum ROM

The 2-way mixed factorial ANOVA determined there was no significant interaction in regards to time x intervention (F = 0.204, $p = 0.897$) or main effect for intervention (F = 0.435, $p = 0.515$), but there was a significant main effect for time (F = 10.063; $p = \leq 0.001$). It was observed that maximum ROM was greater at 30 minutes post-intervention than pre-intervention ($p \leq 0.001$), post-intervention ($p \leq 0.001$), and 10-minutes post-intervention ($p = 0.002$).

TABLE IV: Descriptive statistics for Maximum ROM data across all six available time points.

Max ROM (Degrees)			
		Graston	**Control**
		Mean (SD)	Mean (SD)
Time Point	Pre- Intervention	101.41 (16.2)	98.17 (9.5)
	Post - Intervention	103.94 (17.2)	101.17 (13.1)
	10 - Min Post	106.82 (16.2)	101.92 (13.6)
	20 - Min Post	106.88 (15.3)	103.92 (15.2)
	30 - Min Post	110.12 (17.2)	106.25 (11.6)
	48 - Hr Post	106.24 (18.4)	102.17 (12.5)

CHAPTER V

CONCLUSION & DISCUSSION

After completing a review of the literature, it demonstrated that a majority of information on Graston Technique (GT) had been presented in the form of case studies in which GT was one of many treatment variables applied, making it very difficult to attribute clinical gains to the GT alone. Minimal controlled research studies have been conducted to examine the sole effects of GT outside of these conditions. No literature was reviewed that would suggest the effects of solely GT interventions on MTS and flexibility has ever been researched. Therefore this study utilized college-aged students to examine the effects of single-session GT intervention on MTS and flexibility.

Following in-depth statistical analysis of all data, it was concluded that a single session GT intervention presented no short-term or long-term effect on MTS or PT when compared to control subjects. However statistical analysis provided results consistent with other MTS studies that showed that passive stiffness increased as joint angle increased.[18, 21] Both Ryan et al[21] and Palmer et al[18] found that as they increased the joint angle, MTS also increased. As found within our study (GT versus Control), Ryan et al[21] also determined that regardless of the subjects intervention the increase in MTS was greater as the joint angle increased.

After concluding that GT had no short-term or long-term effect on MTS or PT, it was observed that max ROM was significantly greater at 30 minutes post-intervention when compared to pre-intervention, post-intervention, as well as 10 and 20 minutes post-intervention for both GT and control groups. These measurements could have supported the hypothesis that when GT is used as an independent intervention, subjects would exhibit significantly greater hamstring flexibility immediately post-intervention, as well as 10, 20, and 30 minutes post-intervention when compared to their control counterparts. However, no significant interaction between time and intervention was observed to indicate that GT directly contributed to the increases seen when multiple stretches were performed. The lack of significance at the 48-hour post-intervention time point when compared to the control group does support the idea that a single session GT intervention would not have long-term effect on hamstring flexibility as most subjects had returned toward baseline following 24 hours rest.

Contrary to previous literature that expressed the use of repeated sessions of GT intervention [3,4,5,6,7,11], our study examined only the effects of a single session and it's relation to MTS and flexibility. With the significant increase in flexibility coming at the 30 minute post-time point across both groups it could be concluded that the increase in flexibility was attributed more to the repeated maximum ROM stretching as opposed to intervention.

Recommendations & Clinical Application

As shown through the review of multiple case studies, GT can be an effective supplement to treatment protocols for musculoskeletal injuries.[3,4,5,6,7,11] However, when examined in this study as a stand-alone modality, minimal effects were observed in regards to MTS and flexibility of the hamstrings. Previous case studies show that positive clinical outcomes can be obtained when utilizing GT in combination with passive and active warm-up, therapeutic exercise, and/or other modality. [3,4,5,6,7,11] As with our study, a commonly examined clinical outcome amongst the case studies was ROM. Multiple studies found that significant increase in ROM could be attained when incorporating GT into their treatment protocols.[5,11] While, our study did not indicate any significant changes in ROM from GT interventions alone, the previously mentioned case studies presented findings that would continue to support the use of GT within treatment protocols.

Also, after examining the effects that a single-session GT intervention had on MTS and flexibility, the findings presented ideas that would support the previous literature. Although information was presented in the form of case studies, they were all consistent in that the GT interventions occurred numerous times throughout their protocol. All subjects presented with positive treatment outcomes when treated with more than one session of GT. [3,4,5,6,7,11] With that being said, clinicians should continue to utilize the previous literature until the single-session effects of GT interventions on MTS and flexibility can be evaluated using the recommended areas of future research.

Limitations

The limited amount of statistical significance could be attributed to a number of factors that were a factor throughout the data collection of the study. An original number of 30 subjects were recruited to participate in the study, however during the conversion of files it was determined that one subject's files had been corrupted and were excluded from the study, leaving 29 subjects for data analysis. Also, a total of 5 subjects were unable to complete the 72-hour post-intervention time point measurement due to inclement weather, which closed the University. The choice to forgo the 72-hour measurement was made to ensure subject safety. However, eliminating those subjects from analysis entirely greatly reduced statistical power and the decision was made to analyze only the pre-intervention, post-intervention, 10-, 20-, 30- minute, and 48- hour post-intervention time points. Also, no gender differences were analyzed due to uneven numbers between male and female participants. Although minimal statistical significance was found following analysis of the available data, numerous trends were observed that could indicate the possibility for positive long-term effects of a single-session GT intervention on MTS and flexibility.

Future Research

After expressing how these results and limitations lead us to our conclusions it has revealed the possibility for numerous follow-up studies. Areas of interest for futures studies should continue to focus on the effects of GT on MTS and flexibility however modifying other dependent variables. The identified trends lead us to believe that GT could have a long-term effect on MTS and flexibility in future research, therefore simply having greater subject numbers within the same research model may be able to further evaluate this hypothesis. Also, as single session GT intervention was able to indicate trends toward significant long-term effects on MTS and flexibility, possible duration and specificity of the intervention should be modified within the same research model to better evaluate the hypothesis to determine possible significance.

However as GT has never been previously researched regarding MTS and majorly explained from its use in case studies as only a part of treatment protocols. Future research should also look to evaluate GT and its effect on MTS compared to control subjects while in conjunction with a full therapeutic treatment protocol. This research should look to utilize GT interventions in combination with passive warm-up, therapeutic exercise, and/or other methods of soft-tissue mobilization.[3,4,5,6,7]

As it was also observed in the multiple case studies examining treatment outcomes with GT interventions, numerous sessions of GT were being provided to the clients within the studies.

However, none of these case studies examined the effects on MTS, therefore future research needs to continue to exam the effects of numerous GT interventions on MTS and flexibility when it is performed both alone and as part of an extensive treatment protocol.

Along with examining all of the discussed areas of research, it should be considered that in each of the case studies presented, the clinicians were all working with individuals with different pathological conditions in which they presented with some type of affected musculoskeletal tissue.[3,4,5,6,7] Within this study, it the effects of isolated single-session GT interventions were only performed on healthy individuals without any type of pathological musculoskeletal tissue. This is another area to which a lack of statistical significance could be attributed and further researched. By examining the effects of an isolated single-session GT intervention on individuals with musculoskeletal pathologies in which flexibility deficits or MTS increases are present, those individuals may present with significant improvements in flexibility and decreases in MTS. Continuing to research the effects of GT on hamstring flexibility and MTS using the recommended modifications to the research model will allow us to better identify the most effective way in which to utilize GT interventions in the future.

Conclusion

After reviewing the literature and examining the effects of a single session GT intervention on hamstring MTS and flexibility it has been concluded that while this study did not present results that would support effectiveness from one-time use, previous literature does support the use of GT as an effective treatment for numerous musculoskeletal injuries and conditions. [3,4,5,6,7,8] As a majority of the previous literature was presented in the form of case studies in which GT interventions were applied as part of a treatment protocol or even individually over a course of numerous treatments, this study attempted to examine primarily the effects of a single session GT on hamstring MTS and flexibility. Also with a majority of the literature on GT still residing in case studies, more research should be conducted to better understand the effects of GT on MTS and flexibility. While few significant effects were observed following a single-session GT intervention in this study, the aforementioned ideas for future research should provide multiple opportunities to further investigate the effects of GT on MTS and flexibility.

REFERENCES

1) Kmiecik J, Frattini C, DiNicola A, Wallace S, Cooper K. *ART vs. Graston and Their Effects on Hamstring Flexibility.* September 2011. Accessed February 2012.
2) Davidson CJ, Ganion LR, Gehlsen GM, Verhoestra B, Reopke JE, Sevier TL. *Rat Tendon Morphological and Functional Changes Resulting from Soft Tissue Mobilization.* Medicine & Science in Sports & Exercise, Vol 29(3), March 1997, 313-319.
3) Howitt S, Wong J, Zabukovec S. *The Conservative Treatment of Trigger Thumb using Graston Techniques and Active Release Techniques.* Journal of the Canadian Chiropractic Association. 2006; 50(4). 249-254.
4) Papa JA. *Conservative Management of Achilles Tendinopathy: A case report.* Journal of the Canadian Chiropractic Association. 2012; 56(3). 216-224.
5) Papa JA. *Two Cases of Work-Related Lateral Epicondylopathy treated with Graston Technique and Conservative Rehabilitation.* Journal of the Canadian Chiropractic Association. 2012; 56(3) 192-200.
6) Howitt S, Jung S, Hammonds N. *Conservative Treatment of a Tibialis Posterior Strain in a Novice Triathlete: A Case Report.* Journal of the Canadian Chiropractic Association. 2009; 53(1). 23-31.
7) 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.* Journal of the Canadian Chiropractic Association. 2011; 55(4). 269-279
8) Howitt S. *Lateral Epicondylosis: A case study of conservative care Utilizing ART and Rehabilitation.* Journal of the Canadian Chiropractic Association. 2006;50(3). 182-189.
9) Stow R. *Instrument Assisted Soft Tissue Mobilization.* International Journal of Athletic Therapy & Training. 2011; 16(3).
10) Graston Technique. *History of the Graston Technique Page.* http://grastontechnique.com/AboutUs/CompanyHistory.html. Accessed September 26, 2013.
11) Melham TJ, Sevier TL, Malnofski MJ, Wilson JK, Helfst RH. *Chronic Ankle Pain and Fibrosis Successfully Treated with a New Non-Invasive Augmented Soft Tissue Mobilization Technique (ASTM): A Case Report.* Medicine & Science in Sport & Exercise. 1998. 30(6). 801-804.
12) Loghmani MT, Warden SJ. *Intrsument-Assisted Cross-Fiber Massage Accelerates Knee Ligament Healing.* Journal of Orthopedic & Sports Physical Therapy. 2009; 39(7). 506-514.

13) Gehlson GM, Ganion LR, Helfst R. *Fibroblast Responses to Variation in Soft Tissue Mobilization Pressure.* Medicine & Science in Sports & Exercise. 1999; 31(4): 531-535.
14) Gleim GW, McHugh MP. *Flexibility and its Effects on Sports Injury and Performance.* Sports Med. 1997; 24(5), 289-299.
15) Safran MR, Garrett Jr WE, Seabar AV, Glisson RR, Rebbeck BM. *The Role of Warmup in Muscular Injury Prevention.* The American Journal of Sports Medicine 1988; 16(2) 123-129
16) Cross KM, Worrell TW. *Effects of a Static Stretching Program on the Incidence of Lower Extremity Musculotendinous Strains.* Journal of Athletic Training 1999;34(1) 11-14.
17) Shrier I. *Does Stretching Improve Performance? A Systematic and Critical Review of the Literature.* Clinical Journal of Sports Medicine. 2004; 14(5) 267-273.
18) Palmer TB, Jenkins ND, Cramer JT. *Reliability of manual versus automated techniques for assessing passive stiffness of the posterior muscles of the hip and thigh*. Journal of Sport Sciences. 2013; 31(8) 867-877.
19) Marshall PW, Cashman A, Cheema BS. *A randomized controlled trial for the effect of passive stretching on measures of hamstring extensibility, passive stiffness, strength, and stretch tolerance.* Journal of Science and Medicine in Sport. 2011; 14 535–540.
20) Schleip R, Findley TW, Chaitow L, Huijing PA. *Fascia: The Tensional Network of The Human Body.* Churhill Livingstone Elsevier; 2012.
21) Ryan ED, Beck TW, Herda TJ, Hull HR, Hartman MJ, Costa PB et al. *The time course of Musculotendinous Stiffness Responses Following Different Durations of Passive Stretching.* Journals of Orthopedic & Sports Physical Therapy. 2008; 38(10) 632-639.
22) Spina, A. *Treatment of Proximal Hamstring Pain using Active Release technique applied to the Myofascial Meridian: A Case Report* http://www.sportsperformancecentres.com/assets/articles/Scientific%20Review%20Articles/Treatment%20of%20Proximal%20Hamstring%20Pain%20using%20Active%20Release%20Technique.pdf. Accessed April 15, 2014.

APPENDICES

APPENDIX A: INSTITUTIONAL REVIEW BOARD APPROVAL

Oklahoma State University Institutional Review Board

Date:	Friday, June 07, 2013
IRB Application No	ED12165
Proposal Title:	Effects of Single-Session Graston Technique on Hamstring Flexibility and Muscle Stiffness in Recreationally Active Individuals
Reviewed and Processed as:	Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 6/6/2014

Principal Investigator(s):

Nathan J. Hoffmeier 4599 N. Washington St. #41 Stillwater, OK 74075	Ty Palmer 192 Colvin Center Stillwater, OK 74078	Jennifer Volberding 180 Colvin Center Stillwater, OK 74078
Aric Warren 194 Colvin Center Stillwater, OK 74078		

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

X The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI, advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Cordell North (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Shelia M. Kennison

Shelia Kennison, Chair
Institutional Review Board

APPENDIX B:

INSTITUTIONAL REVIEW BOARD PROTOCOL MODIFICATION APPROVAL

Oklahoma State University Institutional Review Board

Date:	Tuesday, July 30, 2013	**Protocol Expires:**	**6/6/2014**
IRB Application No:	ED12165		
Proposal Title:	Effects of Single-Session Graston Technique on Hamstring Flexibility and Muscle Stiffness in Recreationally Active Individuals		
Reviewed and Processed as:	Expedited **Modification**		

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s):

Nathan J. Hoffmeier
4599 N. Washington St. #41
Stillwater, OK 74075

Ty Palmer
192 Colvin Center
Stillwater, OK 74078

Aric Warren
194 Colvin Center
Stillwater, OK 74078

Jennifer Volberding
180 Colvin Center
Stillwater, OK 74078

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

The reviewer(s) had these comments:

minor modification to add a 4th session to measure hamstring flexibility and stiffness 72 hours post intervention.

Signature :

Shelia M. Kennison

Shelia Kennison, Chair, Institutional Review Board

Tuesday, July 30, 2013
Date

APPENDIX C: INFORMED CONSENT

ADULT CONSENT FORM

OKLAHOMA STATE UNIVERSITY

PROJECT TITLE: Effects of Single-Session Graston Technique on Hamstring Flexibility and Muscle Stiffness in Recreationally Active Individuals

INVESTIGATORS: Aric Warren, EdD, ATC, LAT; Nathan J. Hoffmeier, ATC, LAT
Jennifer Volberding, PhD, ATC; Ty Palmer, MS
Matthew O'Brien, Ph.D., ATC, LAT

PURPOSE:
This research study will examine the effects of The Graston Technique (a type of muscle massage) compared to no treatment (control group) on flexibility and stiffness of the hamstring muscles. The primary goal of the research study is to determine if The Graston Technique can be used to increase the amount of hamstring muscle flexibility and decrease muscle stiffness after a single intervention.

PROCEDURES:
In this study you will participate in three sessions. The *1st session* will act as a familiarization session to introduce you to the study. You will complete the health history questionnaire to see if you meet the criteria to participate in this research. Your height, weight, and cross-sectional area of the hamstring will be collected using a standard scale and tape measure. You will be introduced to the soft-tissue mobilization technique (Graston Technique). Briefly, this involves the use of stainless steel instruments applied to the leg in a stroking motion, very similar to massage. **A video of the technique is provided for you to view prior to consent in this study.* The stroking motions will last 30 – 60 seconds. You will also be introduced to the hamstring stretch used in this study to evaluate hamstring flexibility. This will involve lying on your back on a machine with your leg straped into a leg splint. The machine will move your leg up (similar to a typical hamstring stretch) at a very slow rate for 15-30 seconds that is controlled by a computer. The stretch will be taken to your maximum tolerated range of that movement and then will be stopped.

Session 2 your hamstring flexibility and muscle stiffness will first be measured on the machine. After which you will be randomly assigned to receive the soft tissue massage or no treatment. The massage treatment using the stainless steel instruments will involve sweeping strokes up and down the back of your thigh for 5 minutes. The "no treatment" group will sit comfortably for 5 minutes. Immediately after treatment your hamstring muscle flexibility and stiffness will again be measured using the machine, and again at 10, 20 and 30 minutes after treatment. A total of 8 stretches will be performed on each subject.

Session 3 will take place 48 hours later, where your hamstring muscle flexibility and stiffness will be measured one time.

Session 4 will take place 72 hours later, where your hamstring muscle flexibility and stiffness will be measured one time. This will be the final measurement.

RISKS OF PARTICIPATION:
You may experience mild discomfort (similar to an aggressive stretch), reddening of the skin during the procedure, and possible bruising of the skin after the treatment. You will be instructed to verbally indicate your comfort level at all times. If you feel discomfort of any kind during the procedure let the researcher know immediately. Lighter pressure will be applied or you may withdraw from the study at that time. Redness is very common but temporary and only lasts a few minutes. Applying an ice bag after treatment can help reduce potential bruising. An ice bag will be provided at your request. Any medical treatment you feel you might need resulting from the after effects of participating in this study is your sole responsibility.

BENEFITS OF PARTICIPATION: This study will provide useful evidence about hamstring flexibility and if it can be increased through the application of this common technique. Participation in this research is strictly voluntary and you will not receive any compensation.

CONFIDENTIALITY:
The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

CONTACTS:
You may contact any of the researchers at the following addresses and phone numbers should you desire to discuss your participation in the study and/or request information about the results of the study:

Nathan J. Hoffmeier ATC, LAT
Gallagher-Iba Arena,
Dept. of Athletics Oklahoma State University
Stillwater, OK 74078
(513) 313-9895.
nate.hoffmeier@okstate.edu

Aric Warren, EdD, ATC, LAT
Associate Professor/Program Director/Coordinator-HHP
187 Colvin Recreation Center
Stillwater, OK 74078
(405) 744-4060
aric.warren@okstate.edu

If you have questions about your rights as a research volunteer, you may contact;
Dr. Shelia Kennison
IRB Chair
219 Cordell North
Stillwater, OK 74078
405-744-3377
irb@okstate.edu

PARTICIPANT RIGHTS:

I understand that my participation is completely voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation from this research study at any time without any penalty. Should I choose to withdrawal from the study at any time, I understand that there should be no risks involved in doing so. Also, I am aware that if at any time the investigator deems it unsafe for the subject to complete the research study, my participation can be terminated.

CONSENT DOCUMENTATION:

I have been fully informed about the procedures listed for this research study. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:

- I affirm that I am 18 years of age or older.
- I understand my participation in this research study is completely voluntary
- I have no history of acute hamstring muscle group or hip injury within the past 6 months
- I have been symptom free from any chronic hamstring muscle group or hip injury within the past 6 months
- I understand that even though risks are minimal, the administration of The Graston Technique can be uncomfortable throughout the treatment sessions and may leave bruising and soreness in the treated area.
- I understand that the previously mentioned Graston Techniques will be applied by a Graston Technique Certified individual.
- I have no current conditions that would be a contraindication to receiving the treatment
- I understand that I will not be able to participate in the study if I have had an injury to my leg in the past 6 months, or if I have any of conditions listed in the health history questionnaire.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in this research study.

____ _______________________

Signature of Participant Date

I certify that I have personally explained this document before requesting that the participant sign it.

____ _______________________

Signature of Researcher Date

APPENDIX D: DATA COLLECTION SHEET

DATA COLLECTION SHEET

SUBJECT INITIALS ________________ SUBJECT ID# ________________

Gender: __________

Intervention: __________

HT __________ WT ______________

CIRC: ________________

DATA COLLECTION CODE		TIME:
PRE		
POST		
10		
20		
30		
2- Day		
3-Day		

VITA

Nathan Jay Hoffmeier, ATC/LAT

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF A SINGLE-SESSION GRASTON TECHNIQUE ON HAMSTRING FLEXIBILTY AND MUSCLE STIFFNESS OF RECREATIONALLY ACTIVE INDIVIDUALS

Major Field: Health & Human Performance- Applied Exercise Science

Biographical:

Education: Ball State University – Muncie, IN 2007-2011

Completed the requirements for the Master of Science in Health & Human Performance – Applied Exercise Science at Oklahoma State University, Stillwater, Oklahoma in May, 2014.

Completed the requirements for the Bachelor of Science in Athletic Training at Ball State University, Muncie, IN in 2011.

Experience:

OK State Univ. Graduate Assistant Athletic Trainer – M/W Tennis	2013- 2014
OK State Univ. Graduate Teaching Assistant	Fall 2013
OK State Univ. Graduate Assistant Athletic Trainer – Softball	2011-2013
Gatorade Summer Camp Team Leader & Athletic Trainer	2012-2013
Ball State University Football Summer Intern Athletic Trainer	Summer 2011

Professional Memberships: National Athletic Trainer's Association