

THE GRASTON TECHNIQUE® INCREASES HAMSTRING FLEXIBILITY

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FLEXIBILITY

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MASTER OF SCIENCE

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ABSTRACT

Soft tissue mobilization techniques have been reported to increase hamstring flexibility. However, no one has reported the effects of the Graston Technique® on increasing hamstring flexibility. The purpose of this study was to determine the changes in range of motion after applying the Graston Technique® to tight hamstring muscles.

Forty five college-aged students participated; 3 well-trained athletes, 35 physically trained students, and 7 untrained students (total 30 men and 15 women). Pre- and post-treatment measurements on hamstring flexibility were taken at the 90/90° position using a goniometer.

There was a statistically significant difference between the sham treatment group and the treatment groups (an only Graston Technique® group and a whole Graston Technique® treatment group). However, there was no significant difference between the only Graston Technique® group and the whole Graston Technique® treatment group. Also, range of motion increase was affected by the adipose tissue thickness.

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PREFACE

This disquisition came from one seminar course I have taken, the Graston Technique®. In this seminar, everything was interesting to me because the Graston Technique® is a completely different treatment than I have ever learned. This technique is said to be effective on various symptoms and injuries, such as decreasing swelling, increasing range of motion, and healing strains and sprains. I researched this technique. However, I could not find many articles related to this technique. Since that time, I thought that something related to this technique could be my disquisition.

In the seminar, an instructor explained that the Graston Technique® increases range of motion. However, I could not find any articles about it. It is how my disquisition topic came to be. I spent much time researching the Graston Technique® and the treatment related to this technique. It was the hardest part on this disquisition due to a lack of information. At the same time, one thought came out in my head. This technique could still have potential on various symptoms and injuries.

At the end, I thank you, reader, for having interest to read this disquisition or reading at least this page.

TABLE OF CONTENTS

| | |
|--|-----|
| ABSTRACT | iii |
| ACKNOWLEDGEMENTS..... | iv |
| PREFACE..... | v |
| LIST OF TABLES | x |
| LIST OF FIGURES | xi |
| CHAPTER 1. INTRODUCTION | 1 |
| <i>Statement of the Problem</i> | 2 |
| <i>The Purpose of the Study</i> | 2 |
| <i>Research Questions</i> | 3 |
| <i>Definition of Terms</i> | 3 |
| <i>Assumptions</i> | 3 |
| <i>Limitations</i> | 4 |
| <i>Delimitations</i> | 4 |
| CHAPTER 2. LITERATURE REVIEW..... | 5 |
| <i>IASTM Definition</i> | 5 |
| <i>Indications and Contraindications</i> | 6 |

| | |
|---|----|
| <i>Graston Technique® Introduction</i> | 7 |
| <i>Treatment Process</i> | 8 |
| <i>Advantages and Disadvantages</i> | 8 |
| <i>Theories on each Treatment Process</i> | 9 |
| Warm up (Heat) | 9 |
| The Graston Technique® | 11 |
| Heat and Massage | 14 |
| Fascia..... | 16 |
| Passive Stretch | 17 |
| Strengthening | 18 |
| Cryotherapy | 19 |
| <i>Graston Technique® Treatment on Injuries</i> | 19 |
| <i>Conclusions and Future Research</i> | 24 |
| CHAPTER 3. METHODS..... | 25 |
| <i>Experimental Design</i> | 25 |
| <i>Population of the Study</i> | 26 |
| <i>Instruments</i> | 27 |

| | |
|---|----|
| <i>Procedures</i> | 30 |
| <i>Statistical Analysis</i> | 32 |
| CHAPTER 4. JOURNAL OF ATHLETIC TRAINING | 33 |
| <i>Abstract and Key Words</i> | 34 |
| <i>Introduction</i> | 35 |
| <i>Methods</i> | 36 |
| Experimental Design..... | 36 |
| Participants | 37 |
| Procedures | 38 |
| Statistical Analysis | 40 |
| <i>Results</i> | 40 |
| <i>Discussion</i> | 42 |
| <i>Clinical Implication/Future Research</i> | 46 |
| <i>Conclusion</i> | 47 |
| <i>References</i> | 55 |
| CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS | 57 |
| <i>Discussion</i> | 58 |

| | |
|--|----|
| <i>Conclusion</i> | 64 |
| <i>Recommendations for Future Research</i> | 64 |
| <i>Recommendations Regarding Utilization of Findings</i> | 65 |
| REFERENCES | 67 |

LIST OF TABLES

| <u>Table</u> | <u>Page</u> |
|--|-------------|
| 3.1. Mean and standard deviation of subjects' age, weight, height, and adipose tissue thickness..... | 26 |
| 4.1. Mean and standard deviation of subjects' age, weight, height, and adipose tissue thickness..... | 48 |
| 4.2. Average of adipose tissue thickness, ROM, and standard deviation on each group..... | 49 |
| 4.3. Adipose tissue thickness in group 2 and 3..... | 50 |
| 4.4. Mean pre and post ROM difference between groups..... | 51 |
| 5.1. Average of adipose tissue thickness, ROM, and standard deviation on each group | 58 |
| 5.2. Adipose tissue thickness in group 2 and 3..... | 60 |
| 5.3. Mean pre and post ROM difference between groups..... | 61 |

LIST OF FIGURES

| <u>Figure</u> | <u>Page</u> |
|---|-------------|
| 3.1. Graston Technique® instruments | 27 |
| 3.2. The measurement method..... | 28 |
| 3.3. Two poles with a string and strap to hold down subjects' another leg | 29 |
| 3.4. GT1, 3, and 4 instruments used in the present study | 31 |
| 4.1. The measurement method..... | 52 |
| 4.2. Two poles with a string and strap to hold down subjects' another leg | 53 |
| 4.3. GT1, 3, and 4 instruments used in the present study | 54 |

CHAPTER 1. INTRODUCTION

The Graston Technique® is one of the common soft tissue mobilization techniques and is categorized as an Instrument-Assisted Soft Tissue Mobilization (IASTM). It treats a variety of soft tissue injuries, such as sprains, strains, and general dysfunction of soft tissues.¹ Some clinicians have had good results by using this technique, and have found the Graston Technique® to heal soft tissue problems and injuries.² Therefore, the Graston technique® has been used in the medical field lately, especially as a rehabilitative process. The effects of the Graston Technique® have been researched on various types of injuries. However, there are still some unclear topics, such as improvement on range of motion (ROM).

An IASTM is when a clinician manipulates soft tissues with instruments,¹ which helps the recovery of soft tissue injuries and dysfunctions. General soft tissue injuries treated by the Graston Technique® include sprains, strains, and tendinitis.¹ Rehabilitation and treatment are necessary to improve ROM after these injuries and to return to physical activities from injuries. Range of motion is one important factor in performing physical activities and sports. Range of motion can be defined as how much a joint moves.³ Two types of ROM include: active range of motion (AROM) and passive range of motion (PROM). Active range of motion is how much a person can move his/her limb by him/herself.³ Passive range of motion is how much a clinician can move a patient's limb.³ Active range of motion is often used to measure rehabilitative progress,³ and PROM is not only used as a method for assessing ROM, but also to improve ROM, such as a partner stretch. Using IASTM may be able to ease pain and recover damaged muscle fibers with increasing ROM.

The Graston Technique® consists of five phases: warm-up (heat), Graston Technique®, passive stretching, strengthening, and cryotherapy.¹ Each phase has different effects on the

human body, and these effects are thought to heal injured tissues. The warm-up (heat) consists of biking, jogging, or using a warm whirlpool or hot pack. This phase increases tissue temperature and loosens soft tissues, which increases PROM.⁵ Passive stretching is stretching soft tissues and increasing ROM.⁵ Strengthening means therapeutic exercises performed by high repetitions with low intensity. It prevents muscle atrophy and increases local blood flow.⁶ Cryotherapy is cold therapy, and it usually consists of icing. It decreases pain, inflammation, and swelling.⁷ From these processes, ROM should be increased after treatments, and increasing ROM could help the athlete return to competition earlier because injured athletes can move to the next rehabilitation.

Based on the literature review, each process in the Graston Technique® could recover injuries and possibly recover faster. A rehabilitation goal is to return injured tissues to its pre-injury state, and the Graston Technique® is thought to help this process due to increase in ROM and decrease in scar tissues. Returning ROM is one of the most important factors in rehabilitation. The Graston Technique® is thought to increase ROM, thus moving on to the next rehabilitative step earlier. However, how the Graston Technique® increases ROM on tight hamstring muscles is not clear.

Statement of the Problem

The Graston Technique® is used on a variety of injuries and has shown positive effects on injured patients. However, ROM improvement was unclear. The problem was whether the Graston Technique® improves ROM after a treatment or if other phases (stretching and strengthening) were helping to improve ROM.

The Purpose of the Study

The purpose of this study was to determine the changes in ROM after applying the Graston Technique® to tight hamstring muscles.

Research Questions

1. Did the Graston Technique® alone improve ROM on tight hamstring muscles?
2. Did the Graston Technique® with the four phases improve ROM greater than the Graston Technique® alone?

Definition of Terms

Hamstrings: consisted of three muscles; biceps femoris, semitendinosus, and semimembranosus.⁸

Strain: to stretch, partially or completely tear muscles caused by excessive tension within the muscle fibers.⁹

Power skills: motion that requires explosive muscle contractions.¹⁰

Tendinitis: inflammation of tendon usually caused by overuse.¹¹

Range of motion: how much the joint can move.³

Active range of motion: a subject actively contracts his/her muscles and move his/her limb.³

Passive range of motion: a clinician takes the subject's limb and moves his/her limb until the point of pain or end range of motion.³

Assumptions

1. Cryotherapy decreases muscle temperature, so it decreases ROM after the treatment. Therefore, cryotherapy was cut from this study.
2. Passive range of motion measurement of the hamstrings was passive knee extension from 90° of hip flexion.
3. The Graston Technique® lotion was used to make skin and instruments contact smoothly in this research.

Limitations

1. There was no limit on the amount of adipose tissue a subject could have. It might affect the effectiveness of the Graston Technique®.

Delimitations

1. All subjects were free from any skin disorders and open wounds.
2. All subjects were male or female who have had hamstring tightness (A straight leg raise is between 40-70 degrees).
3. All subjects were categorized as untrained, physically trained, and well trained athletes.
4. All subjects received a treatment by the GT 1, GT 3, and GT 4 instrument.
5. Subjects in the control group received a sham Graston Technique® by reversed-handed instrument with a very light stroke.
6. All subjects received a 10 minute hot pack treatment as the warm-up.
7. The Graston Technique® was 10 minutes in duration.
8. The passive stretch was 30 seconds in duration in a fixed hip flexion of 90° with an extended knee.
9. The strengthening section consisted of 15 repetitions of hamstring curls with the subjects in a prone position using the red thera-band (low intensity).

CHAPTER 2. LITERATURE REVIEW

The purpose of this study was to determine the changes in range of motion (ROM) after applying the Graston Technique® to tight hamstring muscles. The following research questions guided this study: 1) Did the Graston Technique® alone improve ROM on tight hamstring muscles?, and 2) Did the Graston Technique® with the three phases (warm up, passive stretching, and strengthening) improve ROM greater than the Graston Technique® alone?

This literature review is about what effects the soft tissue mobilization technique has on the human body and its treatment effect and is organized in the following manner: IASTM definition, indications and contraindications, Graston Technique® introduction, treatment process, advantages and disadvantages, theories on each treatment process, Graston Technique® treatment on injuries, conclusions and future research.

Instrument-Assisted Soft Tissue Mobilization (IASTM) is a soft tissue treatment that uses instruments to achieve soft tissue mobilization.¹ Instrument-Assisted Soft Tissue Mobilization includes the Graston Technique®, Astym, and Sound Assisted Soft Tissue Mobilization (SASTM).¹ These techniques are very useful and can be applied to many types of injuries. In this literature review, the Graston Technique® will be the main focus. The Graston Technique® is said to release fascia, increase blood flow, increase ROM, and heal soft tissues.¹ However, what the Graston Technique® actually does to the human body is unclear.

IASTM Definition

Soft tissue mobilization is defined as a correction to soft tissue problems in muscles, tendons, and fascia caused by the formation of fibrotic adhesions as a result of acute injuries.¹⁵ These adhesions cause muscle, tendon, ligament, and fascia fibers to not function correctly. Soft tissue mobilization includes Active Release Technique, massage, and positional release

therapy.¹⁴ The difference between IASTM and soft tissue mobilization is whether or not a clinician uses instruments. Instrument-Assisted Soft Tissue Mobilization is getting more and more popular now, and new techniques are still emerging. Functional and Kinetic Treatment with Rehabilitation (FAKTR) is one example and is newer than the Graston Technique®.¹⁵ The most known IASTM techniques are the Graston Technique®, Astym, Gua Sha, FAKTR, and Sound Assisted Soft Tissue Mobilization (SASTM).¹

Indications and Contraindications

As a treatment, indications and contraindications are important for all clinicians. Indications are defined as conditions that would benefit from the application of a certain treatment.¹⁶ Contraindications are defined as situations in which a specific treatment should not be used.¹⁶ Indications of IASTM are tendinopathies, such as lateral/medial epicondylitis, Achilles tendinitis, patellar tendinitis, De Quervain's syndrome, and fascial syndromes; such as plantar fasciitis and iliotibial band syndrome.¹ Also, indications include strains and sprains, except during the inflammation period.¹ Instrument-Assisted Soft Tissue Mobilization techniques are used very often in the medical field because these injuries occur not only in sports but also in the general population.^{1,17,18} Contraindications include fresh burn scars, open wounds, rheumatoid arthritis, thrombophlebitis, varicose veins, and any skin infections.¹ Since the equipment touches skin, any skin disorders are contraindicated for this particular treatment. However, once the wound is closed and does not secrete blood or any other fluids, it can become one of the indications for this treatment. This treatment causes tissues to increase collagen formations.¹ In addition, the Graston Technique® can be used for edema reduction if using light strokes.¹

Graston Technique® Introduction

The Graston Technique® courses consist of two parts: Module-I (M-I) basic and Module-II (M-II) advanced.¹ In order to be a certified Graston Technique® provider, the M-II advanced course is required to be completed. However, once the M-I basic course is taken, the individual can provide Graston Technique® treatments. One of the most interesting points in the Graston Technique®, also including all IASTM, is that a clinician can feel the actual soft tissues, giving it a “crunchy” sensation and tightness on the tissues if there is an abnormality. In the Graston Technique®, six pieces of stainless steel instruments are used. Each piece has a different shape and different edges, so it can be applied on various tissue surfaces.¹

Each Graston Technique® instrument has a number on each specific piece of stainless steel: GT1, GT2, GT3, GT4, GT5, and GT6.¹ Each instrument should be used on different body parts. The GT1 instrument is the longest instrument with a single bevel, and it is best used for large areas including the hamstrings, quadriceps, and gluteus muscles.¹ The GT2 instrument has two circular shapes on each side of it; one circular shape has a single bevel, and the other has a double bevel. It is good for treating medium rounded surfaces such as the patellar tendon, forearm, and wrist.¹ The GT3 instrument is similar to a tongue depressor, in the way that one side has a single bevel. It is good for treating smaller areas, and it is usually used after finding tight spots in those small areas.¹ The GT4 instrument is a half-ovular shape, in which the circular side is used for treatments. It is a single bevel and is good for treating medium sized areas.¹ It can be alternated with the GT1 instrument. The GT5 instrument is a concave shape, and also has a single bevel. It has a wider, flat surface to attach with the body surface, and is also a good treatment for circularly shaped areas.¹ The GT6 instrument is the smallest tool in the Graston Technique®, and is very similar to the GT2 instrument. However, it is smaller than the GT2

instrument, so it is good for treating fingers, toes, and hands.¹ Also, the GT6 instrument has a double beveled edge on the end of it. Besides Graston Technique®, each IASTM technique uses different instruments. For example, Astym has three pieces of plastic instruments¹⁸, and FAKTR has four stainless steel instruments as well.¹⁵ Every IASTM technique uses different instruments and different stroke techniques to achieve soft tissue healing.

Treatment Process

Instrument-Assisted Soft Tissue Mobilization is very unique due to the treatment process of each IASTM technique. In the Graston Technique®, the treatment processes consist of five phases: warm up (heat), Graston Technique®, passive stretching, strengthening, and cryotherapy.¹ Astym consists of four steps: warm up, Astym, dynamic flexibility, and eccentric strengthening.¹⁸ Lastly, FAKTR is the most unique in its process. In this treatment, a patient performs strengthening exercises while a clinician treats the patient's tissues simultaneously.¹⁵ From the above, it can be said that every treatment has its own style. Therefore, there are advantages and disadvantages to each.

Advantages and Disadvantages

The main advantage of IASTM is that it is easy to treat everywhere and a comfortable technique for clinicians.¹ Due to using instruments, clinicians do not have to use their hands, and it is easier to treat compared with massage therapy. Also, the instrument is not as large as ultrasound and electrical stimulation machines, so clinicians can carry the Graston Technique® instruments easily. The Graston Technique® instruments are made of stainless steel, and consist of a harder density material than plastic instruments. Therefore clinicians can be more sensitive and gentle with stainless instruments, letting them be able to feel more tightness and more “crunchy” soft tissue areas. This is one of the biggest advantages of the Graston Technique® and

FAKTR.¹ The biggest advantage of Astym is the three plastic instruments. Each piece of instrument has a different shape and size, so it is easy to apply on every part of the body. One of the biggest disadvantages of the Graston Technique® is that it is time consuming.¹ By using five phases, treatments take about 45 minutes on a single patient. However, FAKTR can be performed with rehabilitative exercises, so it is a very quick treatment. The biggest disadvantage of Astym is that all of the instruments are made of plastic. Since plastic is a less dense material than stainless steel, clinicians do not feel a lot of “crunchy” sensations compared with the stainless steel Graston Technique® instruments. Also, it is time consuming due to five phases.¹⁸ Clinicians need to observe what has to be done on injuries and to treat patients accordingly.

Theories on each Treatment Process

Due to the numerous phases of the Graston Technique®, each phase needs to be reviewed thoroughly to fully understand why this treatment is effective. The following process is reviewed: the warm up (heat), the Graston Technique®, passive stretching, strengthening, and cryotherapy.

Warm up (Heat)

In the Graston Technique® treatment, the warm up always needs to be performed first. It depends on what body part will be treated, but walking on a treadmill, biking, and some other exercises can be performed by patients as their warm up.¹ The warm up phase can also include a hot pack or a warm whirlpool instead of exercising.¹ The main reason for the warm up is to increase local blood flow. All of these warm up techniques, exercise and a heating modality, increase blood flow to the tissues.⁶ Another important reason to warm up or heat before the Graston Technique® phase is to cause relaxation of the muscle fibers. In order to contract muscles, the human body uses calcium ions, and the calcium ions bind muscle fibers in a cell.

This binding activity causes muscle contractions. When an exercise or a heating modality is used, the muscles will be relaxed due to the reduction of the calcium permeability, and actomyosin ATPase will be blocked. Calcium helps binding muscle fibers, but due to a heat modality, calcium cannot go through a cell's wall. Therefore, it causes relaxation and loosens muscle fibers.²⁰ Relaxation is good before treating any muscle spasms and any muscle tightness issues and allows the clinician to treat the muscle easily.

It is understood that local heating modalities increase blood flow and body temperature. However, one question keeps arising: Will local heating modalities benefit everyone? The adipose tissue thickness depends on the individual. From a general perspective, people who have thicker adipose tissues will not get the same effect as people who have thinner adipose tissues. One study showed that heat transfer to the muscle in obese or overweight people had a lesser effect with a moist heat pack and a warm whirlpool.²¹ From this study, the change in muscle temperature was decreased by 66% in overweight people compared with thinner people.²⁴ The subjects' body mass index (BMI) average was 25.8 ± 4.6 ,²¹ and 25 or higher is considered overweight on the BMI scale.²² Consideration is needed in using heating modalities with people who have thicker adipose tissues on treatment areas. In the same study, the author recommended using slow heat modalities for overweight people.²¹ If patients are overweight and can move their body freely, they should perform five minutes of bike-riding or similar exercises to warm up.

There is another important reason why a heating modality is used at the beginning of the Graston Technique® treatment. It is to increase joint mobility, to increase connective tissue extensibility, and to reduce pain by heating.²³ The treatment will be much easier if pain is decreased, and with the increase of connective tissue extensibility, a clinician can provide

treatment easier and put more pressure on the instruments. Another benefit of the warm up is to decrease sensitivity.¹ Some patients are ticklish, especially when the treatment is on the plantar surface of feet or the axilla area. Due to the increase in blood flow and warmed up tissues, the treatment areas become desensitized, and clinicians can treat it easily.

The Graston Technique®

As mentioned earlier, the difference between IASTM and massage is using instruments or hands. Massage therapy is included as one of the soft tissue mobilization techniques,¹⁴ so the IASTM itself is considered to cause the same effect as the massage therapy. The main reason clinicians use instruments for soft tissue mobilization is to easily apply pressure and prevent exhaustion.¹ There is a lack of IASTM studies and since the use of hands or instruments is the only big difference, massage is reviewed mainly in this section. Sliz et al.²⁴ observed that Swedish massage causes relaxation and unique effects on the brain. This particular massage group scored the highest on the Positive Affect Negative Affect Scale, which is a 41-item scale made up of several emotion-based constructs. The Positive Affect Negative Affect Scale measure has positive and negative affect sub-scales (10 items each) which evaluate the patient's subjective degree of non-pleasurable and pleasurable feelings. According to this study, Swedish massage consisted of long smooth strokes with pressure.²⁴ The Graston Technique® strokes are the same as Swedish massage strokes, thus causing relaxation. A clinician usually treats the body part with instruments and uses long strokes first with the GT1 instrument for large areas and the GT4 instrument for small and medium areas.¹ The clinician strokes upside a couple times and then strokes downside for a few times.¹ During these strokes, the clinician can find a spot that is tight or has the “crunchy” sensation mentioned earlier.

One reason people get massage therapy is for relaxation and loosening tight muscles. A study showed that massage therapy is an effective modality for pain reduction in Morton's neuroma.²⁵ Morton's neuroma is pain that is caused by a bundle of nerves being pinched between the third and fourth metatarsals, causing burning or sharp pain, and numbness on the forefoot.²⁵ As a treatment, the patient needs to wear shoes with a wide toe box and place a tear drop shaped pad between the third and fourth metatarsal on the plantar side.²⁶ In a rare case, the patient needs to have surgery.²⁶ In this study, a female patient with Morton's neuroma received six massage treatments over one month, once a week for 60-75 minutes, and home exercises which consisted of dorsiflexion without toe flexion.²⁵ Her average pain during an activity was five on the Visual Analog Scale, which has zero (no pain) to 10 (worst pain). After six treatments, the patient's pain decreased from a five to zero.²⁵ Massage decreased her pain in this study. She had a cortisone injection and was recommended to rest by her physician when she was initially diagnosed with Morton's neuroma. This helped the pain temporarily, but the pain returned after exercises were performed.²⁵ From this example, massage therapy sessions plus home exercise were effective in treating her Morton's neuroma.

Also, in the Graston Technique® M-I basic course, instructors discussed the effects the Graston Technique® has on Morton's neuroma, and that Morton's neuroma is due to a nerve impingement, and a clinician needs to use light strokes with light pressure on the skin because this area is sensitive.¹ Using the Graston Technique®, the GT6 instrument has a double beveled edge with small curves and is the best option to treat Morton's neuroma and other small areas of soft tissues. Treatment variety is one of the benefits of IASTM. Each IASTM has different shaped instruments, so they can be easily applied to different types of body tissues. Another

benefit of IASTM, when comparing it to massage which uses a human finger, is that there are no “sharp” edges such as a human nail.

One of the most important effects of IASTM is to increase fibroblasts.¹ A fibroblast is defined as any cell component from which fibers are developed.²⁷ Instrument Assisted Soft Tissue Mobilization causing fibroblasts on the damaged soft tissues is the reason why Achilles tendinitis and other inflammation types of injuries are indications. One study used rats to observe the increase of fibroblasts.²⁸ In this study, rats had an injection which induced tendinitis on the Achilles tendon, and then received soft tissue mobilization with a small adjusted instrument for this small area.²⁸ As a result, there was an observable and statistically significant difference in fibroblast numbers (mean fibroblast cell count in the treated group = 470 and mean fibroblast cell count in the control group [no soft tissue mobilization] = 150) on a treated group.²⁸ This is an animal model study, so the evidence level is very low. However, the same thing could happen in a human body. That is why IASTM can potentially heal and treat tendinitis injuries.

Instrument-Assisted Soft Tissue Mobilization is not only used on injured tissues but also non-injured tissues, especially the Graston Technique® and FAKTR. The reason why these two are better than other IASTM techniques for treatments on non-injured tissues is that the tools’ edges are not too sharp and there is a bigger variety in instruments that can be used. In the Graston Technique®, the longest instrument, called GT1, is used for treating hamstrings, quadriceps, and other large muscle areas and is useful for performing slow and long strokes.¹ Therefore, the Graston Technique® is good for causing relaxation and treating large areas at one time.^{1,24} Also, a massage is effective on injuries such as delayed-onset muscle soreness. There is one study which showed how a massage is effective on delayed-onset muscle soreness. Zainuddin et al.²⁹ tested whether a massage would decrease muscle soreness after 10 sets of 6-

maximal isokinetic eccentric contractions on the elbow flexor muscles, while one arm got a massage and the other did not receive one. The eccentric contractions resulted in delayed-onset muscle soreness and the massage significantly decreased the pain, but there was no significant effect on the recovery of the muscle strength and range of motion.²⁹ Instrument-Assisted Soft Tissue Mobilization, especially the Graston Technique® and FAKTR, can get the same effects as this study.¹ Zainuddin et al.²⁹ also stated that massage had positive effects on plasma creatine kinase activity and swelling reduction. With the Graston Technique®, very light strokes from distal to proximal areas are performed to achieve drainage.¹ Also, the clinician gently shakes the instruments right to left during these strokes, decreasing edema.¹

Heat and Massage

In the previous sections, how the Graston Technique® works and how it affects soft tissues are explained. This section reviews the effects on the human body if heat is applied and then a massage is given. There is one study which examined the effects of heat and massage on autonomic responses.³⁰ Lee et al.³⁰ reported significant decreases in a plasma cortisol level and a plasma norepinephrine level after two weeks. There was not a significant difference between the baseline and four weeks after on the plasma cortisol level, but there was a significant difference between the baseline and four weeks after on the plasma norepinephrine level.³⁰ Norepinephrine was increased under a stressful condition, and cortisol is an important part of the stress response.³⁰ From this, it is understood that people under stressful conditions, working, working out, and writing papers, would increase norepinephrine and cortisol. These hormones interfere with the recovering muscle damage and other soft tissue damage.³⁰ Heat and IASTM treatment can be considered to decrease these hormones because they relax patients.

Range of motion is one of the most important factors in rehabilitative processes and is a required basic element in sports.³¹ People who are injured do not usually have full ROM due to pain or tissue damages.³¹ In the Graston Technique® M-I basic course, instructors taught students that the Graston Technique® helps improve ROM.¹ Some literature reports that improving flexibility is beneficial for decreasing injury risk, reducing post-exercise soreness, and improving coordination.³² One of these studies examined the effects of the soft tissue mobilization technique on ROM. Hopper et al.³² made three experimental groups: control, classic soft tissue mobilization, and dynamic soft tissue mobilization. In the classic soft tissue mobilization group, subjects received a massage based on the Swedish massage technique. In the dynamic soft tissue mobilization group, subjects received the same massage as the classic group, but they also received eccentric contractions with the therapist's resistance and five deep strokes.³² This treatment in the dynamic group is really similar to FAKTR,¹⁵ and shares many similarities with the Graston Technique® and Astym because both IASTM techniques include exercising.^{1, 18} Hopper et al.³² found that the dynamic soft tissue mobilization group had a significant improvement compared with the control and classic soft tissue mobilization groups. From this result, IASTM techniques may increase ROM. Hopper et al. stated the reason why the dynamic group increased ROM in comparison with the classic group, was that the dynamic group performed the eccentric exercise while a therapist delivered deep strokes, causing tightened muscles to elongate and achieve functional length.³² It can be assumed that the same thing would happen in FAKTR, while other IASTM techniques would bring tightened muscles back to normal functioning length due to the strokes used by the tools and focusing on a tightened spot. Also, the warm up (heat) phase helps to increase the tissue temperature and to increase the muscle length.²⁰

Fascia

During treatments, clinicians can feel a “crunchy” sensation, and it is said to be due to the fascia and soft tissue adhesions.¹ Clinicians can also feel tight spots in the muscle belly. This section will focus on these symptoms and review why these symptoms occur. Fascia is defined as the fibrous membrane that covers, supports, and separates muscles.³³ Fascia is a type of tensional structure: if one side pulls, the other side will change shape or get stretched.³⁴ Because of this, some people sometimes feel pain at a particular area even though that spot is not injured, and it is called referred pain in the medical field.³³

Similar to feeling adhesions on the human body, clinicians can also feel trigger points. A myofascial trigger point is defined as a tender spot associated with tightened muscles that produce local pain and sometimes referred pain.³⁵ While palpating, a clinician can sometimes feel tight spots in the muscle belly which indicates a myofascial trigger point. These points need to be loosened to decrease the pain. First, some strokes are performed by a large instrument. In the Graston Technique®, it is the GT1 instrument.¹ After stroking and finding the tight area, small instruments, such as the GT3 and the GT6 instruments, are used to focus on the spot.¹ The reason why people get this myofascial trigger point is due to muscle overuse or direct trauma to the muscle.³⁵ Muscle overload is considered to be the result of repetitive low-level muscle contractions, eccentric muscle contractions, and maximal or submaximal concentric muscle contractions.³⁵ Also, mental stress affects muscle contraction. According to Schleifer et al.,³⁶ trapezius electromyography (EMG) increased while subjects were under a high mental workload doing computer work. Due to high mental stress, desk workers tend to have a higher chance of getting tightness in their upper shoulder.³⁶ Some desk workers complain of a headache, tight shoulder, and tight neck. These symptoms can be due to high stress and bad posture. In the

athletic field, players get nervous under a high pressure game situation or an important part during the game, like a soccer penalty kick. This situation may also cause muscles to tighten.

People feel stress from their everyday jobs, school, or daily activities. Lundberg et al.³⁷ found mentally induced stress keeps low threshold motor units active even though there is no physical movement. In this study, 12 out of 14 subjects had one or more motor units which were found to be active physically, as well as by mentally induced muscle contraction.³⁷ This low threshold motor unit activity develops tight muscles and myofascial trigger points. These tightened spots and myofascial trigger points also decrease blood flow,³⁷ causing poor blood circulation and making symptoms worse and the healing process slower. Relaxation is required with people who have high mental stress because it causes the muscles to loosen.³⁰ Instrument Assisted Soft Tissue Mobilization, especially the Graston Technique®, can induce relaxation during treatments and has quick results after one treatment.¹

Passive Stretch

Stretching is often used to maintain or improve ROM by many people.³⁸ It is easy to perform, and people can perform it anywhere without professionals or tools. The word, “stretch,” sounds really simple, but there are many types of complex stretching techniques. In IASTM, passive stretching is used most often. Passive stretching is a static stretching technique that is performed by another person placing the patient’s limb in a maximal position of stretch and holding it there for 15 to 30 seconds.³⁸ The stretching duration is recommended to be at least 15 to 30 seconds.³⁸ In the Graston Technique®, the recommendation for stretching is one or two sets.¹ However, the number of sets that should be performed is unclear in the literature. Boyce and Brosky³⁹ examined sets of passive stretching on hamstring muscles, and discovered that subjects had the greatest increase in ROM after the first set (about 8 degrees from baseline).

They also reported that there was an insignificant gain after 5 sets.³⁹ Ryan et al.⁴⁰ reported that two sets of 30 second passive stretches decreased musculotendinous stiffness, and they did not observe further reduction on the third and fourth stretches. Yet, stretching can only help some symptoms of injuries. While using the Graston Technique®, there is a passive stretch immediately after the use of the treatment to elongate the tightened spots not found during the initial Graston Technique® treatment because of the length in the deep tight muscles.¹ There is a limitation to treating deep muscles by IASTM, so stretching also has a role to help these muscles. DiGiovanni et al.⁴¹ examined a plantar stretch on subjects with chronic plantar fasciitis and found a significant difference in the pain after 8 weeks. In this study, subjects performed passive dorsiflexion and toe hyperextension with their hand applying the force.⁴¹ Ninety-two percent of patients in the study reported satisfaction for this improvement, and 62% had the best results within six months after this stretching program.⁴¹ Performing stretching exercises after IASTM treatment causes a positive effect for maintaining normal ROM and allowing patients to stretch easily because of the relaxation that occurs.

Strengthening

In the Graston Technique®, the next phase is a strengthening exercise. The strengthening exercise has a very important role in a rehabilitative process. In this phase, patients perform rehabilitative exercises, using two sets of exercises with 12 or more repetitions.¹ The strengthening phase is really important in the rehabilitative processes because injured people need to restore their strength to the same as before the initial injury. One study showed that six weeks of eccentric exercises changed the stiffness in the Achilles tendon, while the concentric exercises did not affect it.⁴² Instrumented-Assisted Soft Tissue Mobilization techniques (the Graston Technique®, Astym, and FAKTR) incorporate eccentric exercises in the strengthening

phase, not only for gaining the patients strength back, but for also loosening stiffness in the patient. In the Graston Technique®, the strengthening step includes both eccentric and concentric motions, which is why this treatment alleviates the loosening of the tightness while patients gain their strength back.^{1, 42}

Cryotherapy

Cryotherapy, or cold therapy, is the most popular and the most often used treatment in the sport medicine field.⁴³ The physiological effects of cold therapy include a decreased temperature, decreased inflammation, decreased pain, decreased muscle spasms, and decreased blood circulation.⁴³ Use of an ice bag is the most commonly used form of cryotherapy.⁴³ The main question that arises with cryotherapy are how long an ice bag should be applied to the tissue. According to Jutte et al.,⁴⁴ cryotherapy duration depends on the patient's adipose tissue thickness and also depends on the depth of the target tissue. Patients with thicker adipose tissues need more time to cool down. From this study, thin areas, such as fingers, toes, and ankles, need less time to cool down. Long et al.⁴⁵ found that patients who exercised before icing decreased the tissue temperature faster than those who went without exercise. They also observed about 13.5 minutes difference to reach 10 °C lower than the baseline temperature between the exercise before the icing group and without exercise group. From this research, the timing of the cryotherapy step in the Graston Technique® phases is perfect because it is followed right after the strengthening phase. In the Graston Technique®, the icing duration depends on the body part and follows the standard icing protocol.¹

Graston Technique® Treatment on Injuries

This section will introduce studies about IASTM performed on injured patients. Some injuries are listed on the section of indications and contraindications mentioned earlier. First, a

study shows a case with a female patient having De Quervain's syndrome over a four month period.⁴⁶ De Quervain's syndrome is a disorder that causes wrist pain and tenderness at the radial styloid process, and is caused by impaired gliding of the abductor pollicis longus tendons and the extensor pollicis brevis muscles.⁴⁶ Papa⁴⁶ reported good results on the female patient with De Quervain's syndrome and treated her with the Graston Technique® and exercises consisting of static stretches and eccentric contractions. She received treatments twice a week in the first four weeks and once a week in the second four weeks. Before the Graston Technique® treatment sessions, the patient visited her physician and received a thumb spica and ibuprofen, but her symptoms did not get better, so she decided to visit Papa's clinic. From the report, her pain scale was around 8/10 on the Verbal Pain Rating Scale (zero means no pain, and 10 means worst pain) at the baseline. After eight weeks, her pain scale became 0/10 at rest and 1-2/10 with activities. The one factor that could affect this result is rest. She received rest from her daily activities, such as laundry, child care, and cleaning while she received the Graston Technique® and stretching treatments. Rest is one of the most important factors in the process of healing injuries, and could affect the healing tissues. However, after the eight weeks, and after her six-month follow-up, her pain scale was still at zero, and she reported no reoccurrence in pain.⁴⁶ The Graston Technique® treatment probably affected an increase in fibroblasts²⁸, resulting in the patient's tendon healing completely and not becoming re-injured. In addition, her tendons and muscles may have also gotten stronger by eccentric exercises.

One common injury the Graston Technique® is performed on is Achilles Tendinitis. It is a common injury, especially in runners.⁴⁷ For this case study, the male patient was a long distance runner (10 km) with Achilles tendinitis for over three years. The patient was prescribed the standard treatments, such as anti-inflammatory medications, rest, therapeutic ultrasound,

general massages, basic calf stretching, needle acupuncture, and physical therapy. These only offered relief immediately after the sessions but did not help long term. After deciding to quit these treatments, the patient went to the Miner's clinic and received a moist heat pack treatment, the Graston Technique® treatment, an Active Release Technique, slow eccentric calf lowering exercises, and a static stretch with an ice bag. In this study, the GT3 instrument was used to treat the Achilles tendon. He received these treatments twice a week for three weeks and was also provided with additional treatments every seven to ten days. His pain scale was ranging from 6-7/10 at the beginning, and became 3-4/10 at the sixth visit, and 0-1/10 at the end of the treatment sessions. After seven months, he reported the same pain free condition at the end of his treatment sessions.⁴⁷ This result is significant due to the symptoms he had that lasted over three years, and that he also received standard treatments for tendinitis before the successful treatments. These standard treatments usually consist of anti-inflammatory drugs, therapeutic ultrasound, exercises, and icing. In this study, twice a week treatments decreased symptoms within four weeks. The Graston Technique® treatment is recommended two or three times a week,¹ due to the injured tissues that require time for healing. During weight lifting, the same muscle groups should not train within 74 hours of each other due to the impairment of gaining and recovering muscles.⁴⁸ Treatment pressure of the strokes is controlled by the clinician, but can sometimes cause soreness or minor pain during the initial treatment due to the breaking down of adhesions and the loosening of tight muscles.¹ This means that injured tissues are stressed during their treatment, so this is why recovery time is required between each treatment. This recovery time makes for stronger fibers and increases fiber elasticity.⁴⁷

A third study reported on patients with chronic plantar heel pain due to plantar fasciitis.⁴⁹ In Looney's study, 12 subjects were included in this study, and received eight sessions of the

Graston Technique® treatment once or twice a week over three to eight weeks with a home stretching program three times a day.⁴⁹ Their Lower Extremity Functional Scale (LEFS) score was 65 or less. The Lower Extremity Functional Scale is a measure of activity limitation developed for musculoskeletal conditions of the lower extremity.⁵⁰ On this scale, subjects rate the difficulty in performing 20 activities of the lower extremity on a 5-point scale (0= extremely difficult and 4= easy).⁵⁰ A score range is from 0 to 80, with 0 indicating high level of activity limitation and 80 indicating low level of activity limitation.⁵⁰ Even though two subjects dropped due to having contraindications for the treatment and having LEFS score greater than 65, 7 of 10 participants had a greater outcome, and pain scores were also significantly dropped from a baseline mean pain score of 5.8 and follow-up mean pain score of 2.7 (zero means no pain, and 10 means worst pain).⁴⁹ Chronic pain was reduced after three to eight weeks.

In the previous sections, the effectiveness of the Graston Technique® with various injuries was explained. Another study illustrates the effectiveness of the Graston Technique® on post-surgery treatments. According to the Graston Technique® M1-basic training seminar, this treatment helps for building collagen and fibers after surgery.¹ In this study from Black,⁵¹ a male patient with his patellar tendon ruptured received surgery and took 10 weeks to achieve 90 degrees of knee flexion. He received five treatments over a four week period, which consisted of a warm up, the Graston Technique®, patellar or femoral joint mobilization, flexion ROM exercise, strengthening, and an ice bag with an electrical stimulation treatment. His pain scale decreased 5/10 to 0/10 on the numeric pain scale (zero means no pain, and 10 means worst pain) at the end of the fourth session. His active ROM increased to 110 degrees at the fifth visit.⁵¹ He had quick results due to the traditional Graston Technique® treatment. However, there are two differences from the original treatment, which included the joint mobilization technique and the

addition of electrical stimulation treatment with the icing, which could have also affected the results. This patient achieved passive ROM from 95 degrees at the baseline to 123 degrees at the fifth session.⁵¹ It is a good result for post-surgery on a knee, especially achieving it within four weeks. To gain 90 degrees at knee flexion, he spent 10 weeks.⁵¹ From this, clinicians can see how the Graston Technique® used with other treatments may increase ROM.

In addition, there is one study which showed positive results by combining the Graston Technique® with an active release technique. In this study from Howitt et al.,⁵² a patient with trigger thumb, which is a disorder of entrapment of the flexor digitorum superficialis or flexor digitorum profundus tendon, received eight treatments of the Active Release Technique and the Graston Technique® over a four week period. By the sixth treatment, the subject gained full ROM with no pain, but their strength was still 4/5 at the flexor pollicis longus. At the eighth session, he had full ROM without pain, and after 2-14 months, he did not report any pain or ROM problems. There is a similarity between the studies reviewed in this section, all patients had a tendon problem. Instrument-Assisted Soft Tissue Mobilization seems to work very well on tendon injuries. It is thought to be because IASTM increases fibroblasts.²⁸ Howitt et al. stated the Graston Technique® helped remove adhesions and promoted the recovery of the normal tissue texture, while surgery is another option to treat this injury.⁵² However, thinking about rehabilitative processes and the time it takes for recovering from the actual surgery, the Graston Technique® and the Active Release Technique gave a patient with trigger thumb positive enough results. Some patients may be afraid of surgery, so this approach would be beneficial for these particular patients.

Conclusions and Future Research

There are many studies reviewed in this literature review. There are a few subtle differences between the IASTM techniques and massage therapy, and there are some differences in the application of treatments in each study. As explained in the Graston Technique® section, the main concept is the same, whereas massage therapy is also one of the soft tissue mobilization techniques.¹⁴ The only difference between IASTM and massage therapy is that clinicians use their hands as the instruments. Both the IASTM techniques and massage techniques showed good results for improving the condition in each study,^{24, 25, 26, 29, 30, 32, 41, 49, 51, 52} especially on tendon injuries. Each step has its own purpose, such as to elongate tissues, to increase fibroblast, to decrease pain, and to decrease inflammation. As the instructor in the Graston Technique® M-I basic course stated, this technique is very effective, especially on tendon issues, superficial muscle issues, and soft tissue tightness.¹ Clinicians can get quick results after a single treatment or multiple treatments. It is achieved due to the effectiveness of every single phase (warm-up, Graston Technique®, passive stretch, strength, and cryotherapy). However, IASTM still needs to be researched more, and have studies on only the IASTM treatments (excluding heat, stretch, strength, and cryotherapy). Also, whether this treatment really causes either fibroblast production or an increase in fibroblasts on a human body needs to be researched. One of the best benefits of IASTM is that it is effective for every person including age, sex, and sport levels.¹ This is the biggest reason that IASTM techniques are used in the sports medicine, physical therapy, and chiropractic fields.¹ From this literature review, it can be concluded that IASTM is effective on soft tissue injuries because of the reasons listed above, and can help a lot of injuries of different kinds and also all kinds of people.

CHAPTER 3. METHODS

The purpose of this study was to determine the changes in range of motion (ROM) after applying the Graston Technique® to tight hamstring muscles. The following research questions guided this study: 1) Did the Graston Technique® alone improve ROM on tight hamstring muscles? and 2) Did the Graston Technique® with the three phases (warm up, passive stretching, and strengthening) improve ROM greater than the Graston Technique® alone? This Chapter focuses on who could be the subjects, how the subjects were collected, and how the research was performed. It is organized in the following manner: experimental design, population of the study, procedures, instruments, and statistical analysis.

Experimental Design

A 1×3 (ROM difference and treatment groups) factorial design was used in the experiment. The range of motion difference consisted of pre- and post-treatment measurements. Subjects were randomly assigned to one of three groups: (1) Sham Graston Technique®, (2) only Graston Technique®, and (3) Whole Graston Technique® treatment. The sham Graston Technique® group (the control group) received a hot pack and a sham Graston Technique®. The sham Graston Technique® consisted of using a different edge of Graston Technique instruments with very light strokes. The only Graston Technique® group (group 2) received a hot pack and Graston Technique®. The whole Graston Technique® treatment group (group 3) received a hot pack, Graston Technique®, passive stretch, and strengthening. The dependent variable was passive range of motion (PROM), and the independent variables were the type of treatments (Sham Graston Technique®, only Graston Technique®, and whole Graston Technique® treatment).

Population of the Study

Forty five subjects who had not had any hamstring injuries within 2 months were recruited in this study. Participants were college students who were untrained, physically trained, and well-trained. Physically trained subjects were defined as working out 2-3 times week, and well-trained subjects were defined as Division I collegiate athletes. Both males and females between the ages of 18-50 were included in this study. Subjects had to have hamstring tightness which ranged between 40 to 70 degrees of a straight leg raise.³² Based on a similar study, 45 subjects were needed for this study.³² Subjects' data is listed on Table 3.1.

Table 3.1: Mean and standard deviation of subjects' age, weight, height, and adipose tissue thickness

| | Age | | Weight | | Height | | BF Thickness | |
|---------------|------------|------|---------------|-------|---------------|------|---------------------|------|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Female | 21.73 | 2.37 | 69.37 | 15.71 | 168.48 | 9.38 | 1.08 | 0.44 |
| Male | 20.9 | 2.8 | 88.32 | 15.54 | 182.58 | 6.61 | 0.85 | 0.36 |

*SD=Standard deviation.

Subjects were excluded if they had any hamstring injuries within 2 months. Subjects who had any skin infections were excluded because it is one of the contraindications in the Graston Technique®.¹ Also, subjects who had any surgeries on their lower extremities within the last 6 months were excluded. Subjects who had lumbar disc herniation and lower limb neurological compromise were excluded. The study was accepted by the University's Institutional Review Board, and all subjects signed a consent form.

Instruments

Graston Technique® instruments consist of various shapes of six stainless sticks. These instruments have a model number on each tool, and they are GT1, GT2, GT3, GT4, GT5, and GT6 (TherapyCare Resources Inc., Indianapolis, IN) (Figure 3.1).



Figure 3.1. Graston Technique® instruments. Mentioned on page 26. Left top: GT4, right top: GT5, top middle: GT6, left middle: GT3, right middle: GT2, bottom: GT1

In this experiment, GT1, GT3, and GT4 were used. The GT1 is the longest instrument, and it is good for large areas such as the gluteus maximus, hamstrings, quadriceps, and upper trapezius muscles. The GT1 has a curve on the middle of the instrument, called a concave edge, and it is a single bevel. The GT3 is a straight thin instrument, and it is the same shape as a tongue depressor. It is single bevel, and has a convex edge. This instrument is good for small areas, such as the patellar tendon, joint line, and any small points on muscles. The GT4 is a single bevel and has a convex edge. This shape is similar to a half of an ellipse, and the curved side is used for treatments.

A standard plastic 360° goniometer (The Therapy Connection, Windham, NH) was used for the pre and post treatment measurements (Figure 3.2).



Figure 3.2. The measurement method.

To prevent cheating, two poles were put between the end of the treatment table and a wall, and each pole was connected with a string. This stand was set at the 90° flexion point. This stand was hand made (Figure 3.3).



Figure 3.3. Two poles with a string and strap to hold down subjects' another leg.

The Terason t3200™ Diagnostic Ultrasound (MedCorp, LLC., Tampa, FL) was used to provide an image of the adipose tissue thickness on hamstrings. Aquasonic® 100 ultrasound gel (Parker Laboratories, Inc., Fairfield, NJ) was applied to the 15L4 Linear transducer (4.0-15.0 MHz) (MedCorp LLC, Tampa FL) to perform this technique. The transducer was placed over the middle part of the hamstrings, and the image was frozen. The adipose tissue thickness was checked by the caliper mode on the diagnostic ultrasound, and the thickness was recorded. The thera-band red color (The Hygenic Corporation, Akron, OH) was used for the strengthening phase.

Procedures

Before testing, the subjects kept their life styles, but they were asked to avoid working out 72 hours before the experiment. Also, the subjects were asked to avoid any stretching exercises 72 hours before the experiment. On the experiment day, the Graston Technique® was explained to the subjects. However, the subjects were not informed of how many groups existed and which group they were in. Also, the subjects were not informed of the sham Graston Technique®. After the explanations, all subjects signed a consent form, and if a subject did not agree with it, he/she was rejected from this study.

Before starting any treatments, the hamstring area was observed by a diagnostic ultrasound machine to measure the adipose tissue thickness. Next, PROM was measured with the subject in a supine position with the hip flexed to 90° (Figure 3.3). The tester passively extended the subject's knee until the subject reported feeling discomfort. Three goniometric measurements were taken, and the average was calculated as the final measurement. After measurements, subjects drew a folded piece of paper that had a group number on it and handed it to the researcher. Subjects did not know which group they were assigned.

Each group started the experiment with a hot pack (warm up) treatment. From the Graston Technique® course, the warm-up section is about 10 minutes if a hot pack is used or a few exercises which include the body part to be treated if exercises are performed. In this study, hot pack was used due to convenience. After 10 minutes, the hot pack was removed from the hamstring muscles. The only Graston Technique® group and the whole Graston Technique® treatment group received the typical Graston Technique® consisting of six-ten long strokes by the GT1 instrument, ten-fifteen short strokes on the small areas by the GT4 instrument, and one minute very short strokes on the small spots by the GT3 instrument (Figure 3.4). This cycle were

performed until a stop watch beeped. The treatment duration was 10 minutes. The sham treatment group also received 10 minutes of a treatment, but this treatment was a sham since the other side of the instruments were used with really gentle strokes.

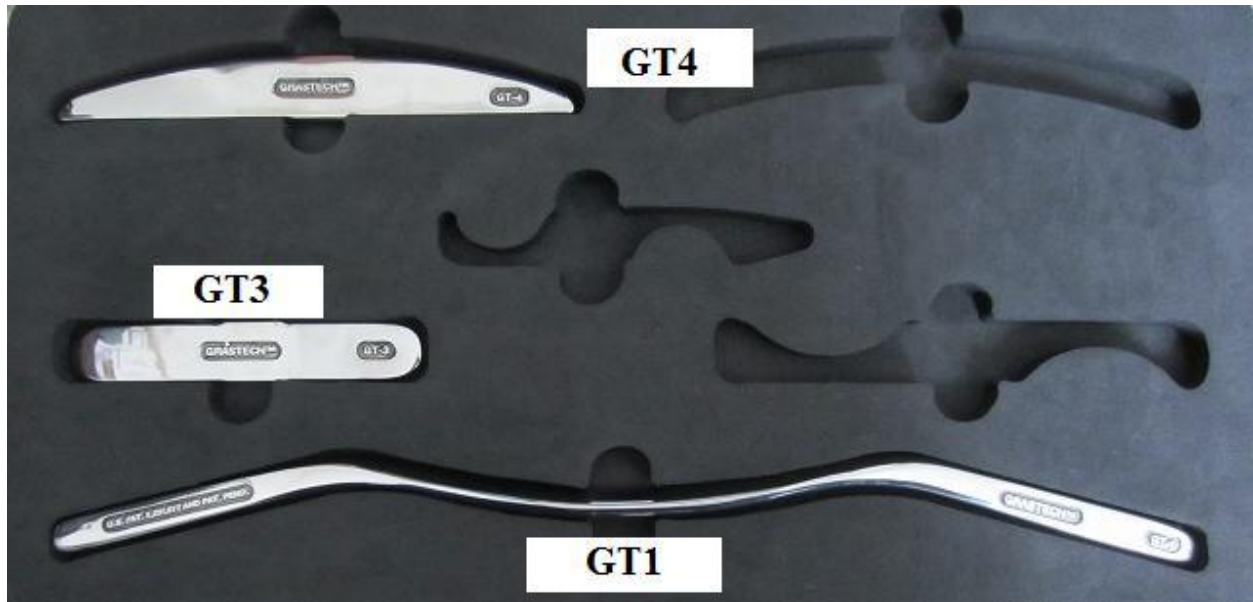


Figure 3.4. GT1, 3, and 4 used in the present study.

After 10 minutes, the sham and only Graston Technique® groups had PROM measurements by a goniometer. The post-treatment PROM measurement procedures were the same as the pre-treatment measurement procedures. In the whole Graston Technique® treatment group, the subjects received passive stretching immediately after the Graston Technique®. The passive stretching was the same as the PROM measurement procedure, and the holding duration was a standard static stretching duration of 30 seconds. It was performed twice. The reason why stretching was performed twice is that the Graston Technique® course recommends stretching two or three times.¹ After the passive stretching, this group performed strengthening exercises which consisted of hamstring curls with an elastic band. The subjects performed two sets of 15 repetitions. After the strengthening phase, PROM was measured by the same procedure as the

pre-treatment measurement. To prevent false measurements, practice sessions were performed on three individuals who were not included in the real experiment. This helped to prevent threats to internal validity. At the end of the experiment, the sham Graston Technique® group received an actual Graston Technique® treatment, so all subjects equally received the Graston Technique® treatment.

Statistical Analysis

The mean pre and post treatment measurements for the sham Graston Technique® group, the only Graston Technique® group, and the whole Graston Technique® group was analyzed with 1×3 (ROM difference and treatment groups) one-way ANOVA to assess differences between groups. (ROM difference = post-treatment measurement – pre-treatment measurement) Tukey's HSD post-hoc test was used to compare the difference between groups. Independent samples t-tests were used to see differences between male and female and also between untrained and physically trained subjects. All statistical analysis was calculated by IBM SPSS Statistics version 21 (2013, IBM). P-value was set as $P < 0.05$.

CHAPTER 4. JOURNAL OF ATHLETIC TRAINING

The Graston Technique® Increases Hamstring Flexibility

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The Graston Technique® Increases Hamstring Flexibility

Abstract and Key Words

Context: Soft tissue mobilization techniques have been reported to increase hamstring flexibility. However, no one has reported the effects of the Graston Technique®, a type of Instrument-Assisted Soft Tissue Mobilization (IASTM) techniques, on increasing hamstring flexibility. **Objective:** The purpose of this study was to determine the changes in ROM after applying the Graston Technique® to tight hamstring muscles. **Design:** Randomized controlled clinical trial. **Setting:** Laboratory. **Patients or Other Participants:** Forty five college-aged students participated: 3 well-trained athletes (2 men, 1 woman), 35 physically trained students (24 men, 11 women), and 7 untrained students (4 men, 3 women). **Intervention:** Pre- and post-treatment measurements on hamstring flexibility were taken at the 90/90° position using a goniometer. **Main Outcome Measure(s):** Knee range of motion in degrees. **Results:** There was a statistically significant difference between the control group (a sham Graston Technique® group) and the treatment groups (an only Graston Technique® group and a whole Graston Technique® treatment group) ($F_{2,42}=15.77, P<0.001$). However, there was no significant difference between the only Graston Technique® group and the whole Graston Technique® treatment group. Range of motion increase was affected by the adipose tissue thickness (more than 1.0 cm). **Conclusions:** The Graston Technique® increased hamstring flexibility. Gender and activity level did not have an effect on the results. However, the effectiveness was decreased on the subjects with adipose tissue thickness over 1.0 cm. **Key Words:** adipose tissue, Graston Technique®, hamstring flexibility, IASTM, Instrument Assisted Soft Tissue Mobilization

Introduction

The Graston Technique® is used on a variety of injuries and has been shown to have positive effects on injuries, such as Achilles tendinopathy, plantar fasciitis, and De Quervain's stenosing.^{1,2,3} However, there are still some unclear topics, such as improvement on range of motion (ROM). The Graston Technique® is one of the common soft tissue mobilization techniques and is an Instrument-Assisted Soft Tissue Mobilization (IASTM).⁴ It treats a variety of soft tissue injuries, such as sprains, strains, and general dysfunction of soft tissues.⁴ Some clinicians have had positive results by using this technique and have reported the Graston Technique® to heal soft tissue problems and injuries.^{1,2,3} Therefore, athletic trainers, chiropractors, and other therapists often use the Graston technique® in the medical field lately⁴, especially as a rehabilitative process. While there is some research in the form of case studies on the effects of the Graston Technique®, the evidence is limited.

A technique is considered to be IASTM when a clinician manipulates soft tissues with instruments, which helps recovery on soft tissue injuries and dysfunctions.⁴ General soft tissue injuries treated by the Graston Technique® include sprains, strains, and tendinitis.⁴ Rehabilitation and treatment are necessary to improve ROM after these injuries and to return to physical activities from injuries. The Graston Technique® consists of five phases: warm-up (heat), Graston Technique®, passive stretching, strengthening, and cryotherapy.⁴ Each phase has different effects on the human body in order to heal injured tissues. The warm-up (heat) consists of biking, jogging, or using a warm whirlpool or hot pack. This phase increases tissue temperature and loosens soft tissues, which increases passive range of motion (PROM).⁵ Passive stretching is stretching soft tissues and increasing ROM.⁵ Strengthening means therapeutic exercises performed by high repetitions with low intensity. It prevents muscle atrophy and

increases local blood flow.⁶ Cryotherapy is cold therapy, and it usually consists of icing. It decreases pain, inflammation, and swelling.⁷ From these processes, except cryotherapy, we hypothesized that ROM should be increased after a treatment. Some researchers state that increasing ROM could help with improved athletic performance, reduced injury risk, prevention or reduction of post-exercise soreness, and improved coordination.^{8,9,10} Also, during rehabilitative processes, increasing ROM could help the athlete return to competition earlier because injured athletes can move to the next rehabilitation phase.

The primary author has used the Graston Technique® to treat a variety of injuries, and it has been successful on tendinopathy, pain, and muscle tightness. However, ROM improvement by this technique is unclear. The problem is whether the Graston Technique® improves ROM after a treatment or if other phases (stretching and strengthening) are helping to improve ROM. The purpose of this study was to determine the changes in ROM after applying the Graston Technique® to tight hamstring muscles in healthy individuals.

Methods

Experimental Design

A 1 × 3 (ROM difference and treatment groups) factorial design was used in the experiment. The range of motion difference consisted of pre- and post-treatment measurements. (ROM difference=post-treatment measurement–pre-treatment measurement) Subjects were randomly assigned to one of three groups: (1) Sham Graston Technique®, (2) only Graston Technique®, and (3) Whole Graston Technique® treatment. The sham Graston Technique® group (the control group) received a hot pack and a sham Graston Technique®. The sham Graston Technique® consisted of using a different edge of the Graston Technique® instruments with very light strokes. The only Graston Technique® group (group 2) received a hot pack and

the Graston Technique®. The whole Graston Technique® treatment group (group 3) received a hot pack, the Graston Technique®, passive stretch, and strengthening. The dependent variable was passive range of motion (PROM), and the independent variables were the type of treatments (Sham Graston Technique®, only Graston Technique®, and whole Graston Technique® treatment).

Participants

Forty five subjects who had not had any hamstring injuries within 2 months were recruited for this study. Of these, 3 well-trained collegiate athletes (2 men, 1 woman), 35 physically trained collegiate students (24 men, 11 women), and 7 untrained collegiate students (4 men, 3 women) participated (Men: mean age=20.9±2.8, mean height=182.58±6.61 cm, mean weight=88.32±15.54 kg, mean hamstring adipose tissue thickness=0.85±0.36 cm. Women: mean age=21.73±2.37, mean height=168.48±9.38 cm, mean weight=69.37±15.71 kg, mean adipose tissue thickness=1.08±0.44 cm) (Table 4.1). Physically trained subjects were defined as working out 2-3 times a week, and well-trained subjects were defined as Division I collegiate athletes. Both males and females between the ages of 18-50 were included in this study. Subjects had to have hamstring tightness ranges between 40 to 70 degrees. Based on a similar study, 45 subjects were needed for this study.¹¹

Subjects were excluded if they had any hamstring injuries within the past 2 months. Subjects who had any skin infections, had any surgeries on their lower extremities within the last 6 months, and had lumbar disc herniation and lower limb neurological compromise were excluded. The University's Institutional Review Board checked all procedures and approved the study, and all subjects signed a written consent form.

Procedures

Before testing, the subjects kept their life styles, but we asked subjects to avoid working out 72 hours before the experiment. We also asked subjects to avoid any stretching exercises 72 hours before the experiment. On the experiment day, we explained the Graston Technique® to the subjects. However, the subjects did not know how many groups existed and which group they were in. Also, the subjects were not informed of the sham Graston Technique®. After the explanations, all subjects signed a written consent form.

Before starting any treatments, we measured the adipose tissue thickness over the mid-hamstring area with a Terason t3200™ Diagnostic Ultrasound (MedCorp, LLC., Tampa, FL) machine. Aquasonic® 100 ultrasound gel (Parker Laboratories, Inc., Fairfield, NJ) was applied to the 15L4 Linear transducer (4.0-15.0 MHz) (MedCorp LLC, Tampa FL) to perform this technique. Next, we measured PROM with the subject in a supine position with the hip flexed to 90° (Figure 4.1). The tester extended the subject's knee until the subject reported feeling discomfort. A standard plastic 360° goniometer (The Therapy Connection, Windham, NH) was used in this experiment. Three goniometric measurements were taken, and the average was calculated as the final measurement. To prevent cheating, two poles were put between the wall and the treatment table, and each pole was connected with a string. This string held the subjects' leg at the 90° hip flexion point. The stand was hand made (Figure 4.2). After measurements, subjects drew a piece of paper, which had a group number written on it, from a box and handed it to the tester. Subjects did not know which group they were assigned.

Each group started the experiment with a hot pack (warm up) treatment. The treatment duration was 10 minutes. After 10 minutes, we removed the hot pack from the hamstring

muscles. The only Graston Technique® group and the whole Graston Technique® treatment group received the typical Graston Technique® consisting of six-ten long strokes by the GT1 instrument, ten-fifteen short strokes on the small areas by the GT4 instrument, and one minute of very short strokes on the small spots by the GT3 instrument and repeated until the 10 minute treatment was completed (TherapyCare Resources Inc., Indianapolis, IN) (Figure 4.3). The sham treatment group also received 10 minutes of a treatment, but this treatment was a sham since the other side of the instruments were used with gentle strokes. A soft tissue mobilization emollient by Graston Technique® (Mansfield-King, LLC, Indianapolis, IN) was used for better instrument sliding on the skin in all groups.

After the 10 minute treatment, the sham and only Graston Technique® groups had PROM measurements by a goniometer. The post-treatment PROM measurement procedures were the same as the pre-treatment measurement procedures. In the whole Graston Technique® treatment group, the subjects received passive stretching immediately after the Graston Technique®. The passive stretching was the same as the PROM measurement procedure, and the holding duration was a standard static stretching duration of 30 seconds. Subjects received static stretching twice. After the passive stretching, this group performed strengthening exercises which consisted of hamstring curls with a Thera-band red color (The Hygenic Corporation, Akron, OH). The subjects performed two sets of 15 repetitions. After the strengthening phase, PROM was measured by the same procedures as the pre-treatment measurement. We removed the cryotherapy part due to causing tissue tightness. To prevent false measurements, we performed three practice sessions on three individuals who were not included in the real experiment.

Statistical Analysis

The range of motion difference of pre- and post-treatment measurements for the sham Graston Technique® group, the only Graston Technique® group, and the whole Graston Technique® treatment group was analyzed with 1×3 (ROM difference and treatment groups) one-way ANOVA to assess differences between groups (ROM difference=post-treatment measurement–pre-treatment measurement). A Tukey’s HSD post-hoc test was used to compare the difference between groups. Independent samples t-tests were used to see differences between males and females and also between untrained and physically trained subjects. All statistical analysis was calculated by IBM SPSS Statistics version 21 (2013, IBM). P-value was set at $P < 0.05$.

Results

The mean increase in ROM was $0.55^\circ \pm 6.182$ (group 1, control group), $9.13^\circ \pm 5.858$ (group 2, only Graston Technique® group), and $14.67^\circ \pm 8.472$ (group 3, whole Graston Technique® treatment group) (Table 4.2). There was a significant difference between groups ($F_{2,42}=15.77$, $P<.001$). The Tukey’s HSD post hoc tests revealed that the only Graston Technique® group and the whole Graston Technique® treatment group had significant ROM increase compared to the control group [mean difference= 8.57 ± 2.533 , $p=0.004$ (the only Graston Technique® group and the control group) and mean difference= 14.11 ± 2.533 , $p<0.001$ (the whole Graston Technique® treatment group and the control group)]. However, there was no significant ROM difference between the only Graston Technique® group and the whole Graston Technique® treatment group (mean difference= 5.54 ± 2.533 , $p=0.085$) (Table 4.2).

We also made three groups, which were categorized by the adipose tissue thickness, in the only Graston Technique® group (group 2). In this analysis, the adipose tissue thickness was categorized as *a*, *b*, and *c*. The group *a* had adipose tissue thickness less than 0.5 cm, and this group had 3 subjects. The group *b* had adipose tissue thickness between 0.5-0.99 cm, and this group had 8 subjects. The group *c* had adipose tissue thickness more than 1.0 cm, and this group had 4 subjects. A one-way ANOVA followed by Tukey's HSD post hoc test was performed for this analysis. The data analysis showed the following results: mean=8.87°±1.03 (group *a*), 12.5°±5.31 (group *b*), and 2.58°±2.46 (group *c*). The mean body fat thickness in each group is the following: 0.430±0.036 cm (group *a*), 0.834±0.094 cm (group *b*), and 1.543±0.548 cm (group *c*). There was a significant difference between groups ($F_{2, 12}=7.252$, $P=0.009$). The Tukey's HSD post hoc test revealed that group *b* had a significant difference compared with group *c* (mean difference=9.93±2.61, $P=0.007$) (Table 4.3).

We also used independent samples t-tests to see differences between male and female subjects in both the only Graston Technique® (group 2) and the whole Graston Technique® treatment (group 3) groups. In group 2, there were 12 males and 3 females. The mean ROM gain was the following: 9.817°±4.909 (male) and 6.367°±9.664 (female). There was no significant difference between males and females [$t(13)=-0.906$, $P=0.381$]. In group 3, there were 9 males and 6 females. The mean ROM gain was the following: 14.60°±9.766 (male) and 14.767°±6.954 (female). There was no significant difference between males and females [$t(13)=0.036$, $P=0.972$].

We also used independent samples t-tests to see a difference between untrained and trained subjects in the only Graston Technique® group (group 2) and the whole Graston Technique® treatment group (group 3). Due to low subject numbers, well-trained and physically

trained subjects were combined into one group, called trained subjects. Also, this analysis was to compare the effectiveness of the Graston Technique® on a variety of people, so we made these untrained and trained groups. The mean ROM gain in group 2 was the following: $7.68^{\circ} \pm 5.687$ (untrained) and $9.65^{\circ} \pm 6.099$ (trained). There was no significant difference between the untrained and trained subjects [$t(13) = -0.564$, $P = 0.582$]. The mean ROM gain in group 3 was the following: $5.70^{\circ} \pm 10.324$ (untrained) and $16.046^{\circ} \pm 7.707$ (trained). There was no significant difference between the untrained and trained subjects [$t(13) = -1.716$, $P = 0.110$].

Discussion

In subjects from the present study, hamstring flexibility improved by using the Graston Technique. Both groups, the only Graston group and the whole Graston treatment group, improved hamstring flexibility significantly more than the control group. By a single session, the only Graston treatment group increased ROM $9.13^{\circ} \pm 5.858$, the whole Graston treatment group increased ROM $14.67^{\circ} \pm 8.472$, and the control group increased ROM $0.55^{\circ} \pm 6.182$ (Table 4.2).

One possible reason for why the Graston Technique improved hamstring flexibility is relaxation. The Graston Technique strokes are similar to Swedish massage strokes which are slow and long.¹² These strokes might cause muscle relaxation which result in tissue elongation. Also, another possibility is that the Graston Technique breaks down adhesions. Adhesions can be built up by a natural process of healing or a protective role for loads due to stress or tension.¹⁰ According to the Graston Technique, this technique breaks down adhesions and helps healing processes.² Also, another study which showed Active Release Technique (ART) increased hamstring flexibility stated that ART releases the adhesions and provides functional improvement sufficient to increase healing and performance.¹⁰ Active Release Technique is one

of the soft tissue mobilization techniques, so the Graston Technique, IASTM, causes the same effect. These reasons could be why the Graston Technique improved hamstring flexibility.

However, the Graston Technique seemed to be less effective on individuals who had the adipose tissue thickness more than 1.0 cm. In group 2, we observed that some people increased hamstring ROM dramatically, but some did not. Since heat and cold modalities are affected by the body fat thickness^{13, 14}, effectiveness of IASTM may also be obstructed by the adipose tissue. To see the effectiveness affected by the adipose tissue thickness, a one-way ANOVA followed by Tukey's HSD post hoc test was performed on group 2. The reason why group 3 was rejected from this one-way ANOVA analysis was that group 3 contained passive stretching and strengthening phases. In this analysis, the adipose tissue thickness was categorized as *a*, *b*, and *c*. The group *a* had the adipose tissue thickness less than 0.5 cm, and this group had 3 subjects. The group *b* had the adipose tissue thickness between 0.5-0.99 cm, and this group had 8 subjects. The group *c* had the adipose tissue thickness more than 1.0 cm, and this group had 4 subjects. (Table 4.3). One-way ANOVA showed there was a significant difference between groups, and the Tukey's HSD post hoc test revealed that group *b* had a significant difference compared with group *c*. From this result, we could actually state that the adipose tissue thickness affected increase in ROM by the Graston Technique®. However, there were no significant differences between male and female and between untrained and trained subjects.

Even after the hot pack treatment, subjects did not increase ROM much in the group *c* of group 2. This data also supports Petrofsky's case study.¹³ In Petrofsky's study, the overweight subject had an adipose tissue thickness of 0.83 cm on quadriceps muscle.¹² In the present study, the mean adipose tissue thickness of group 2 was 0.942 ± 0.484 cm, so there is a similarity between Petrofsky's study and the present study even though measured body parts were

different. From Petrofsky's study, the overweight subject increased in skin temperature, but did not have much of an increase in muscle temperature within 10 minutes.¹³ It can explain why subjects in the group *c* of the group 2 did not increase in hamstring flexibility from the hot pack and Graston treatments in the present study. Also, if there are more tissues between muscles and skin surfaces at which the Graston Technique instruments touch, the pressure created by instruments may not reach to target muscles. In thinner people, the pressure should easily reach the muscles due to less tissues between muscles and skin surfaces. Future research should compare various pressures on subjects who have adipose tissue thickness more than 1.0 cm.

Although the increase in ROM was not statistically different, group 3 increased more compared with the group 2 (Table 4.4). This may have clinical significance. The differences between group 2 and group 3 were passive stretching and strengthening phases, and group 3 had both passive stretching and strengthening phases. These differences could explain why group 3 increased in hamstring flexibility compared with group 2. Boyce and Brosky examined the minimum number of passive stretches on plantar flexor muscles necessary to reduce musculotendinous stiffness. From the Boyce and Brosky's study, the greatest increase in ROM occurred between the first stretch and the second stretch. Also, they reported that researchers observed ROM increase until the sixth set of stretching, so they suggested that two stretches consisting of holding 30 seconds may be necessary to decrease musculotendinous stiffness of plantar flexor muscles.¹⁵ In the present study, the group 3 subjects received two sets of 30 seconds of passive static stretching. This difference explains why the group 3 subjects increased in more ROM in the present study. In addition, passive static stretching is effective in increasing the length of muscle because it allows the muscle spindle to adapt to the length and decrease

firing.¹⁶ The stretching phase can be why there was a difference in ROM increase between group 2 and group 3.

Another difference between group 2 and group 3 is the strengthening phase. Group 3 had two sets of 15 repetitions of hamstring curls with a low intensity Thera-band. This phase might affect the ROM increase in group 3. According to Nelson and Bandy, an eccentric exercise increases hamstring flexibility, and there was no difference between the static stretching group and the eccentric exercise group.¹⁶ In Nelson and Bandy's study, a straight leg eccentric exercise was used.¹⁶ In the present study, the exercise consisted of hamstring curls, so the exercise had both concentric and eccentric contractions. However, this strengthening phase followed by the passive stretching phase might have resulted in more ROM in group 3.

One possible reason for why both passive stretching and strengthening phases could increase hamstring flexibility is that people with the adipose tissue thickness more than 1.0 cm in group 3 also increased hamstring flexibility. The mean ROM increase of group 2 *c* was $2.58^{\circ} \pm 2.46$, and the mean ROM increase of group 3 *c* was $11.67^{\circ} \pm 9.13$ (Table 4.3). This result can explain how subjects in group 3 *c* increased in hamstring flexibility. Since adipose tissue thickness was similar in group 2 *c* and group 3 *c*, the subjects in group 3 *c* had to increase ROM by either one or both passive stretching and strengthening phases. Also, we ran independent t-test between these two groups, and the test showed these two groups were marginally significantly different. To support this test, future studies need a larger sample size. As described in the previous section, passive static stretching increases ROM due to muscle spindles decreasing firing.¹⁶ Passive stretching techniques can be applied to everyone. It should not matter the body size, sex difference, and adipose tissue thickness. From the results in the present study, subjects in group 3 *c* fit into this theory. Also, there is a study showing warm up exercises help improve

flexibility.¹⁷ In the present study, the strengthening phase consisted of low-intensity hamstring curls, so this exercise could be similar to a warm up. Light exercises can increase muscle temperature.¹⁷ This explains how subjects in group 3 *c* increased in hamstring flexibility even though subjects in group 2 *c* did not increase hamstring flexibility much.

Clinical Implication/Future Research

From the results of the present study, the Graston Technique® increases hamstring flexibility on healthy people with tight hamstring muscles. Also, clinicians can use the Graston Technique® on anyone. It does not matter the gender and activity level. However, some people may not have a positive result. It seems to be affected by the adipose tissue. Since some research has shown that heat and cold modalities are less effective of heating muscle on overweight people^{14, 15}, the Graston Technique® could also be limited by the adipose tissues. Clinicians should consider where they apply this technique on their patients and should think about the adipose tissue thickness or if patients have adipose tissue thickness more than 1 cm, clinicians should perform the whole Graston Technique® treatment.

Our study was limited to the effects of the only Graston Technique® and whole Graston Technique® treatment on hamstring flexibility of healthy subjects. Further studies are needed to determine if the Graston Technique® improves hamstring flexibility on injured subjects and also decreases scar tissue after hamstring injuries. Also, future researchers should check how long the increase will last. Another limitation to our study is that subjects had various adipose tissue thickness. For future studies, researchers should set up categories of the adipose tissue thickness and compare each group to see ROM increases. Also, in the present study, moderate pressure

was applied, so in future research, researchers should apply various pressures on the various adipose tissue thickness.

Conclusion

Data showed that the Graston Technique® improved hamstring flexibility, and both the only Graston Technique® and whole Graston Technique® treatment groups improved range of motion significantly. This study included subjects who are untrained, physically trained, and well trained. Physically trained was defined as working out 2-3 times a week, and well-trained was defined as Division I collegiate athletes. From the results, the Graston Technique® is effective on a variety of people. Also, this study included both genders (male=30 and female=15). It also supports that the Graston Technique® improves hamstring ROM without gender difference. The Graston Technique® is useful for people who have tight hamstring muscles and can be used on both genders and without considering the activity level.

Table 4.1: Mean and standard deviation of subjects' age, weight, height, and adipose tissue thickness

| | <u>Age</u> | | <u>Weight</u> | | <u>Height</u> | | <u>BF Thickness</u> | |
|----------------------|-------------------|------|----------------------|-------|----------------------|------|----------------------------|------|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| <u>Female</u> | 21.73 | 2.37 | 69.37 | 15.71 | 168.48 | 9.38 | 1.08 | 0.44 |
| <u>Male</u> | 20.9 | 2.8 | 88.32 | 15.54 | 182.58 | 6.61 | 0.85 | 0.36 |

*SD=Standard deviation.

Table 4.2: Average of adipose tissue thickness, ROM, and standard deviation on each group

| | BF | ROM Difference | SD | Number of Subjects |
|----------------|-----------|-----------------------|-----------|---------------------------|
| Group 1 | 0.798 | 0.55 | 6.18 | 15 |
| Group 2 | 0.942 | 9.13 | 5.86 | 15 |
| Group 3 | 1.036 | 14.67 | 8.47 | 15 |

* BF=adipose tissue thickness. SD=Standard deviation. Group 1=sham Graston group (control group), group 2=only Graston treatment group, and group 3=whole Graston treatment group.

Table 4.3: Adipose tissue thickness in group 2 and 3

| Group | Number of Subjects | Mean | SD |
|------------|--------------------|-------|------|
| 2 <i>a</i> | 3 | 8.87 | 1.03 |
| 2 <i>b</i> | 8 | 12.5 | 5.31 |
| 2 <i>c</i> | 4 | 2.58 | 2.46 |
| 3 <i>a</i> | 0 | 0 | 0 |
| 3 <i>b</i> | 8 | 17.29 | 7.43 |
| 3 <i>c</i> | 7 | 11.67 | 9.13 |

* 2 in the group section means the only Graston treatment group, and 3 in the group section means the whole Graston treatment group. *a*=adipose tissue thickness less than 0.5 cm, *b*=adipose tissue thickness between 0.5 to 0.99 cm, and *c*=adipose tissue thickness more than 1.0 cm. SD=Standard deviation.

Table 4.4: Mean pre and post ROM difference between groups

| | | Mean Difference |
|----------------|----------------|------------------------|
| Group 1 | Group 2 | -8.57 |
| | Group 3 | -14.11 |
| Group 2 | Group 3 | -5.54 |

* Group 1=sham Graston group (control group), group 2=only Graston treatment group, and group 3=whole Graston treatment group.



Figure 4.1: The measurement method



Figure 4.2: Two poles with a string and strap to hold down subjects' another leg

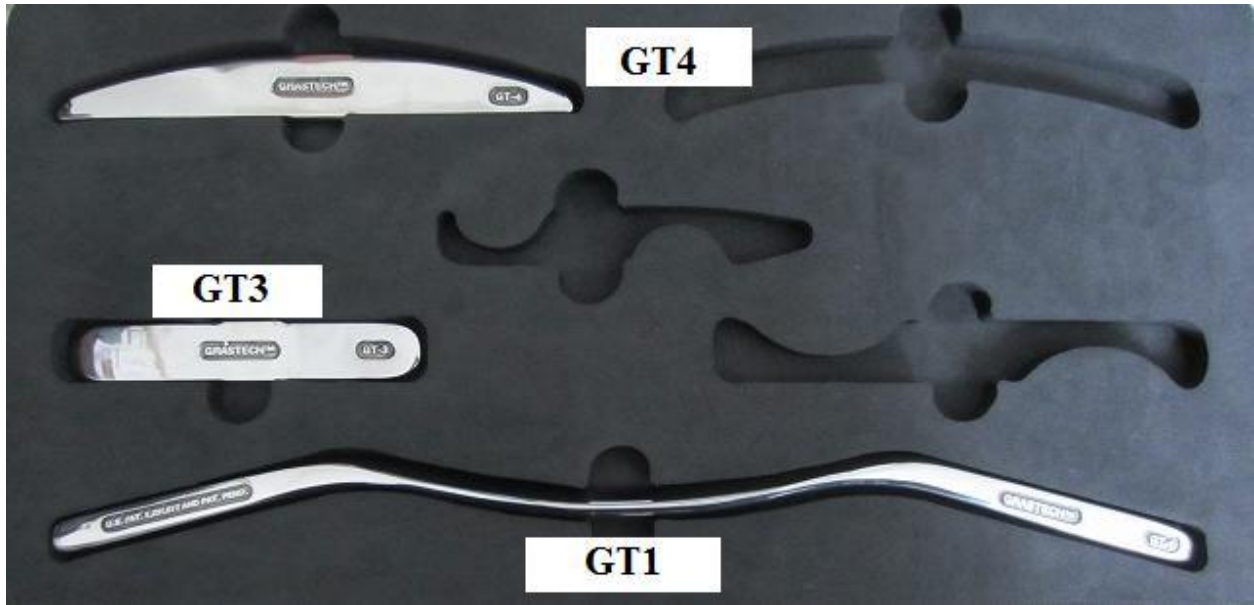


Figure 4.3: GT1, 3, and 4 instruments used in the present study

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CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to determine the changes in range of motion (ROM) after applying the Graston Technique® to tight hamstring muscles. The following research questions guided this study: 1) Did the Graston Technique® alone improve ROM on tight hamstring muscles? and 2) Did the Graston Technique® with the four phases improve ROM greater than the Graston Technique® alone? This chapter focuses on the discussion, conclusions, and future research.

In the Graston Technique®, the treatment processes consists of five phases: warm up (heat), Graston Technique®, passive stretching, strengthening, and cryotherapy.¹ Each process has a purpose based on the effects on the human body. Subjects were randomly assigned to one of three groups: (1) Sham Graston Technique® (control group), (2) only Graston Technique® (group 2), and (3) Whole Graston Technique® treatment (group 3). Subjects blindly picked up the group number from the box. The sham Graston Technique® group received a hot pack and a sham Graston Technique®. The sham Graston Technique® consisted of using a different edge of the Graston Technique® instruments with very light strokes. The only Graston Technique® group received a hot pack and the Graston Technique®. The whole Graston Technique® treatment group received a hot pack, Graston Technique®, passive stretch, and strengthening. The dependent variable was passive range of motion (PROM), and the independent variables were the type of treatments (Sham Graston Technique®, only Graston Technique®, and whole Graston Technique® treatment). Forty five subjects with hamstring tightness (a straight leg raise between 40-70°) were recruited for this study. Measurements by a goniometer were taken before a hot pack treatment and after a sham Graston Technique®, only Graston Technique®, or whole Graston Technique® treatment.

Discussion

In subjects from the present study, hamstring flexibility improved by using the Graston Technique®. Both groups, the only Graston Technique® group (group 2) and the whole Graston Technique® treatment group (group 3), improved hamstring flexibility significantly more than the control group. With a single treatment, the only Graston Technique® group increased ROM $9.13^{\circ} \pm 5.858$, the whole Graston Technique® treatment group increased ROM $14.67^{\circ} \pm 8.472$, and the control group increased ROM $0.55^{\circ} \pm 6.182$ (Table 5.1).

Table 5.1. Average of adipose tissue thickness, ROM, and standard deviation on each group

| | BF | ROM Difference | SD | Number of Subjects |
|----------------|-----------|-----------------------|-----------|---------------------------|
| Group 1 | 0.798 | 0.55 | 6.18 | 15 |
| Group 2 | 0.942 | 9.13 | 5.86 | 15 |
| Group 3 | 1.036 | 14.67 | 8.47 | 15 |

*BF=adipose tissue thickness. SD=Standard deviation. Group 1=sham Graston group (control group), group 2=only Graston treatment group, and group 3=whole Graston treatment group.

One possible reason for why the Graston Technique® improved hamstring flexibility is relaxation. The Graston Technique® strokes are similar to Swedish massage strokes which are slow and long.²⁴ These strokes might cause muscle relaxation to subjects which result in tissue elongation. Also, another possibility is that the Graston Technique® breaks down adhesions. Adhesions can be built up by a natural process of healing or a protective role for loads due to stress or tension.⁵³ According to the Graston Technique®, this technique breaks down adhesions and helps healing processes.¹ Also, the rationale could be similar to a study which showed the effects of Active Release Technique (ART) on hamstring flexibility. In the study, subjects started with a 15 minute light jogging as a warm up, and researchers measured hamstring flexibility by a

sit and reach test. Each subject received an ART treatment on the hamstrings, and researchers measured hamstring flexibility again.⁵³ They reported the mean sit and reach test increased 8.3 cm.⁵³ Researchers stated that ART releases the adhesions and provides functional improvement sufficient to increase healing and performance in the study.⁵³ Active Release Technique is one of the soft tissue mobilization techniques, so the Graston Technique®, IASTM, could cause a similar effect. These reasons could be why the Graston Technique® improved hamstring flexibility.

However, the Graston Technique® seemed to be less effective on individuals who had the adipose tissue thickness more than 1.0 cm. In group 2, some people increased hamstring ROM dramatically, but some did not. Since heat and cold modalities are affected by the adipose tissue thickness, the effectiveness of IASTM may also be obstructed by the adipose tissue. To see the effectiveness affected by the adipose tissue thickness, a one-way ANOVA followed by Tukey's HSD post hoc test was performed on group 2. The reason why group 3 was rejected from this one-way ANOVA analysis was that group 3 contained passive stretching and strengthening phases. In this analysis, the body fat thickness was categorized as *a*, *b*, and *c*. The group *a* had adipose tissue thickness less than 0.5 cm, and this group had 3 subjects. The group *b* had adipose tissue thickness between 0.5-0.99 cm, and this group had 8 subjects. The group *c* had adipose tissue thickness more than 1.0 cm, and this group had 4 subjects. The data analysis showed the following results: mean=8.87°±1.03 (group *a*), 12.5°±5.31 (group *b*), and 2.58°±2.46 (group *c*). The mean body fat thickness in each group is following: 0.430±0.036 cm (group *a*), 0.834±0.094 cm (group *b*), and 1.543±0.548 cm (group *c*). There was a significant difference between groups ($F_{2, 12}=7.252$, $P=0.009$). The Tukey's HSD post hoc test revealed that group *b*

had a significant difference compared with group *c* (mean difference=9.93±2.61, p=0.007) (Table 5.2).

Table 5.2. Adipose tissue thickness in group 2 and 3

| | Number of Subjects | Mean | SD |
|------------|--------------------|-------|------|
| 2 <i>a</i> | 3 | 8.87 | 1.03 |
| 2 <i>b</i> | 8 | 12.5 | 5.31 |
| 2 <i>c</i> | 4 | 2.58 | 2.46 |
| 3 <i>a</i> | 0 | 0 | 0 |
| 3 <i>b</i> | 8 | 17.29 | 7.43 |
| 3 <i>c</i> | 7 | 11.67 | 9.13 |

* 2 in the group section means the only Graston treatment group, and 3 in the group section means the whole Graston treatment group. *a*=adipose tissue thickness less than 0.5 cm, *b*=adipose tissue thickness between 0.5 to 0.99 cm, and *c*=adipose tissue thickness more than 1.0 cm. SD=Standard deviation.

Even after the hot pack treatment, subjects did not increase ROM much in group 2 *c*. This data also supports Petrofsky's case study.²¹ In Petrofsky's study, the overweight subject had an adipose tissue thickness of 0.83 cm on quadriceps muscle.²¹ In the present study, the mean adipose tissue thickness of the group 2 was 0.942±0.484 cm, so there is a similarity between Petrofsky's study and the present study even though measured body parts were different. From Petrofsky's study, the overweight subject increased in skin temperature, but did not have much of an increase in muscle temperature within 10 minutes.²¹ It can explain why subjects in group 2 *c* did not increase in hamstring flexibility from the hot pack and Graston Technique® treatments in the present study. Also, if there are more tissues between muscles and skin surfaces at which the Graston Technique® instruments touch, the pressure created by instruments may not reach the target muscles. In thinner people, the pressure should easily reach the muscles due to less

tissues between muscles and skin surfaces. Future research should compare various pressures on subjects who have adipose tissue thickness more than 1.0 cm.

Although the increase in ROM was not statistically different, group 3 increased more ROM compared with the group 2 (Table 5.3). This may have clinical significance. On hamstring range of motion from the flexed hip at 90°, the maximum range of motion is 135° to 145°. ⁵⁴ About 5° difference between group 2 and group 3 in full range of 135-145° is a big increase in a rehabilitative process. The differences between group 2 and group 3 were passive stretching and strengthening phases, and group 3 had both passive stretching and strengthening phases. These differences could explain why group 3 increased more hamstring flexibility compared with group 2. Boyce and Brosky examined the minimum number of passive stretches on plantar flexor muscles necessary to reduce musculotendinous stiffness. From the Boyce and Brosky study, ³⁹ the greatest increase in ROM occurred between the first stretch and the second stretch. Also, they reported that researchers observed ROM increase until the sixth set of stretching, so they suggested that two stretches consisting of holding 30 seconds may be necessary to decrease musculotendinous stiffness of plantar flexor muscles. ³⁹ In the present study, the group 3 subjects received two sets of 30 seconds of passive static stretching. This difference could explain why the group 3 subjects increased in more ROM. In addition, passive static stretching is effective in increasing the length of muscle because it allows the muscle spindle to adapt to the length and decrease firing. ⁵⁵ The stretching phase can be why there was a difference in ROM increase between group 2 and group 3.

Table 5.3. Mean pre and post ROM difference between groups

| | | Mean Difference |
|----------------|----------------|------------------------|
| Group 1 | Group 2 | -8.57 |
| | Group 3 | -14.11 |
| Group 2 | Group 3 | -5.54 |

* Group 1=sham Graston group (control group), group 2=only Graston treatment group, and group 3=whole Graston treatment group.

Another difference between group 2 and group 3 is the strengthening phase. Group 3 had two sets of 15 repetitions of hamstring curls with a low intensity Theraband. This phase might affect more ROM increase in group 3. According to Nelson and Bandy, an eccentric exercise increases hamstring flexibility, and there was no difference between the static stretching group and the eccentric exercise group.⁵⁵ In Nelson and Bandy's study,⁵⁵ subjects in the eccentric exercise group performed a straight leg eccentric exercise with black Theraband. Subjects brought the right hip into full hip flexion by pulling on the Theraband attached to the foot with both arms, and as subjects pulled the Theraband into full hip flexion with the arms, subjects simultaneously resisted the hip flexion by eccentrically contracting the hamstring muscles during the whole range of hip flexion. These subjects performed this exercise 6 times. Subjects in the static stretching group performed 30 seconds stretching 3 days per week for 6 weeks. After 6 weeks, both the eccentric training and the static stretching groups increased ROM significantly compared with the control group.⁵⁵ In the present study, the exercise consisted of hamstring curls, so the exercise had both concentric and eccentric contractions. However, this strengthening phase followed by the passive stretching phase might have increased more ROM in group 3.

One possible reason for why both passive stretching and strengthening phases could increase hamstring flexibility is that people with the adipose tissue thickness more than 1.0 cm in

group 3 also increased hamstring flexibility. The mean ROM increase of group 2 *c* was $2.58^{\circ} \pm 2.46$, and the mean ROM increase of group 3, *c* was $11.67^{\circ} \pm 9.13$ (Table 5.2). This result can explain how subjects in group 3 *c* increased in hamstring flexibility. Since adipose tissue thickness was similar in group 2 *c* and group 3 *c*, the subjects in group 3 *c* had to increase ROM by either one or both passive stretching and strengthening phases. Also, t-test between these two groups showed these two groups were approaching to significantly different [$t(9) = -1.91$, $P = 0.088$]. To support this test, future research requires larger sample sizes. As described in the previous section, passive static stretching increases ROM due to muscle spindles decreasing firing.⁵⁵ Passive stretching techniques can be applied to everyone. It should not matter the body size, sex difference, and adipose tissue thickness. From the results in the present study, subjects in the group *c* in the group 3 fit into the theory.

There is also a study showing warm up exercises help improve flexibility.⁵⁶ Tsolakis and Bogdanis compared two different warm-up protocols, 5 minute light jogging and either 15 second short or 45 second long stretching, on flexibility. In Tsolakis and Bogdanis's study, subjects performed 5 minutes light jogging and then performed either short or long stretching exercises. Static stretching exercises consisted of three different stretching; unilateral standing quadriceps stretch, unilateral standing hamstring stretch, and unilateral standing calf stretch. For the unilateral standing quadriceps stretch, subjects held the ankle with the ipsilateral hand. For the unilateral standing hamstring stretch, the heel of the foot was placed on an adjustable table slightly below the hip level with the knee fully extended. For the standing calf stretch, the hands were placed against a wall, and the foot was planted on the floor.⁵⁶ Researchers found both short and long stretching groups had a similar increase in hip flexion ROM.⁵⁶ In the present study, the strengthening phase consisted of low-intensity hamstring curls, and the stretching phase

consisted of two sets of 30 second static stretching, so both phases in the present study were similar to Tsolakis and Bogdanis's study. Also, the strengthening phase, hamstring curls with red Theraband, could cause similar effects as 5 minute light jogging. Light exercises can increase muscle temperature.⁵⁶ This explains how subjects in group 3 *c* increased in hamstring flexibility even though subject in group 2 *c* did not increase hamstring flexibility much.

Conclusion

From the present study, the Graston Technique® improved hamstring flexibility, and both the only Graston Technique® and whole Graston Technique® treatment groups improved ROM significantly. This study included subjects who are untrained, physically trained, and well trained. Physically trained was defined as working out 2-3 times a week, and well trained was defined as a Division I collegiate athletes. From the results, the Graston Technique® is effective on a variety of people. Also, this study included both genders (male=30 and female=15). It also supports that the Graston Technique® improves hamstring ROM without gender difference. From this study, the Graston Technique® is useful for people who have tight hamstring muscles (straight leg raise between 40-70°) and helps increasing ROM.

Recommendations for Future Research

This study was limited to the effects of the only Graston Technique® and whole Graston Technique® treatment on hamstring flexibility of healthy subjects. Further studies are needed to determine if the Graston Technique® improves hamstring flexibility on injured subjects. According to the Graston Technique®, this technique decreases scar tissues, so future research should compare the amount of scar tissue before and after a Graston Technique® treatment on hamstring injuries by using a diagnostic ultrasound. Also, future researchers should check how

long the increase will last. Another limitation to this study is that subjects had various adipose tissue thickness. For future studies, researchers should set up categories of the adipose tissue thickness and compare each group to see ROM increases. Also, in the present study, moderate pressure was applied, so in future research, researchers should apply various pressures on the various adipose tissue thickness.

Recommendations Regarding Utilization of Findings

From the results of the present study, the Graston Technique® increases hamstring flexibility on healthy people. Also, clinicians can use the Graston Technique® on anyone. It does not matter the age, gender, and activity level. However, some people may not have a positive result. It seems to be affected by the adipose tissue. Since some research has shown that heat modalities are less effective on overweight people,²¹ the Graston Technique® could also be limited by the adipose tissues. Clinicians should consider where they apply this technique on their patients and should think about the adipose tissue thickness.

As described in the Graston Technique® seminar, this technique can be used as a warm up,¹ so athletic trainers and other clinicians can use the Graston Technique® before practices and games. In this case, athletic trainers and other clinicians use two phases, warm up and Graston Technique®, which help increasing tissue temperature, increasing local blood flow, and elongating muscles.²⁰ As a warm up, it is perfect timing before practices and games for players because it increases tissue temperature, increasing local blood flow, and elongating muscles. This study supports the only Graston Technique® also increases hamstring ROM. The whole Graston Technique® treatment seems to be effective on everyone including people with the adipose tissue thickness more than 1.0 cm, so if a rehabilitative goal is increasing ROM,

clinicians should use all phases, including warm up, Graston Technique®, passive stretching, and strengthening.

A lot of athletic trainers and other clinicians use the Graston Technique®. Some literature reports that improving flexibility is beneficial for decreasing injury risk, reducing post-exercise soreness, and improving coordination.³² From the present study, the Graston Technique® increases hamstring flexibility. However, this technique seems to be affected by the adipose tissue thickness, so athletic trainers and other clinicians should consider where they apply this technique and the adipose tissue thickness.

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