

COMPARISON OF SHORTWAVE DIATHERMY AND INSTRUMENT ASSISTED SOFT  
TISSUE MOBILIZATION ON IMPROVING HAMSTRING RANGE OF MOTION

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Maddie Anne Hansen

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**Title**

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ASSISTED SOFT TISSUE MOBILIZATION ON IMPROVING  
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Maddie Anne Hansen

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The Supervisory Committee certifies that this *disquisition* complies with North Dakota  
State University's regulations and meets the accepted standards for the degree of

**MASTER OF SCIENCE**

SUPERVISORY COMMITTEE:

Kara Gange, PhD, ATC, LAT

---

Chair

Katie Lyman, PhD, ATC, NREMT, CKTF

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Rachelle Vettern, PhD

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Approved:

4-9-19

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Date

Dr. Yeong Rhee

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Department Chair

## ABSTRACT

Limited research exists on the comparison of pulsed shortwave diathermy (PSWD) and instrument assisted soft tissue mobilization (IASTM). In addition, minimal research exists on the AcuForce<sup>®</sup> 7.0 and none of it examines the effects of the AcuForce<sup>®</sup> 7.0 on range of motion (ROM). This study focused on the comparison of PSWD and IASTM on hamstring flexibility and perceived patient comfort.

Twenty male students, faculty, and staff (age  $24.5 \pm 5.7$  years) participated. Active knee extension ROM with the hip flexed at  $90^\circ$  was measured before and after the intervention. Perceived patient comfort was measured after the intervention. The results showed significant increases in ROM in all subjects ( $p = 0.013$ ). However, there were no significant differences between groups ( $p = 0.079$ ). Also, there were no significant differences in perceived patient comfort. The results of this study support hamstring flexibility can be increased with the use of either PSWD or the AcuForce<sup>®</sup> 7.0.

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## TABLE OF CONTENTS

ABSTRACT .....	iii
ACKNOWLEDGEMENTS .....	iv
LIST OF TABLES .....	vii
CHAPTER 1. INTRODUCTION .....	1
Purpose of the Study .....	3
Research Questions .....	4
Definition of Terms .....	4
Importance of the Study .....	5
Limitations .....	5
Delimitations .....	6
CHAPTER 2. REVIEW OF LITERATURE .....	7
Thermotherapy .....	7
Superficial vs. Deep Heating .....	8
Shortwave Diathermy .....	11
Effects of PSWD on ROM .....	15
Manual Therapy .....	20
Effects of Manual Therapy on ROM .....	23
Instrument Assisted Soft Tissue Mobilization .....	31
AcuForce <sup>®</sup> 7.0 .....	35
CHAPTER 3. METHODS .....	39
Experimental Design .....	39
Subjects .....	39
Instrumentation .....	40
Procedures .....	41

Data Analysis .....	44
CHAPTER 4. RESULTS .....	46
Descriptive Statistics .....	46
Results .....	47
Summary of Results .....	50
CHAPTER 5. DISCUSSION .....	51
Discussion .....	51
Limitations of the Study .....	58
Recommendations for Future Research .....	60
Conclusion.....	61
REFERENCES .....	63
APPENDIX A. CHATTANOOGA SHORTWAVE DIATHERMY .....	71
APPENDIX B. ACUFORCE® 7.0.....	72
APPENDIX C. HANDMADE APPARATUS .....	73
APPENDIX D. ACTIVITY QUESTIONNAIRE.....	74
APPENDIX E. PATIENT FEEDBACK QUESTIONNAIRE .....	75

## LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Pulsed shortwave diathermy parameters and the corresponding temperature increases ..	13
2. Results of study from Draper et al. (1999) .....	15
3. Pre- and post-range of motion measurements (in degrees) of knee extension (with hip flexed at 90°) throughout the three days of treatment .....	47
4. Perceived patient comfort between the two treatment groups .....	49
5. Patient Feedback Questionnaire results .....	49

## CHAPTER 1. INTRODUCTION

Range of motion (ROM) is defined as the mobility of a joint, influenced by its surrounding tissue (Starkey, 2004). A problem that hinders ROM is muscle inflexibility, which is defined as how well a muscle lengthens through a range of motion. Improving ROM is an important goal in order to prevent injury (Zachezewski, 1989). Researchers report there is a high incidence of musculoskeletal injuries, such as muscle strains and overuse injuries in individuals who have muscle inflexibility (Witvrouw et al., 2003; Ekstrand and Gillquist, 1983; Krivickas and Feinberg, 1996). Improving ROM is also vital to regain normal muscle function after an injury and prevent further injury from occurring (Bandy, Irion, & Briggler, 1997). There are various treatment methods to increase ROM. Of the various possibilities, thermotherapy and manual therapy are two popular choices to enhance muscle flexibility for an overall increased ROM.

Thermotherapy is the use of a device with higher temperature than the targeted tissue (Knight & Draper, 2013). Hawkes et al. (2013) described some effects of thermotherapy, including: increased circulation, increased metabolism, decreased pain, decreased muscle spasms, and decreased joint stiffness. These effects of thermotherapy are reasons why it is an effective adjunct to stretching when trying to increase ROM (Nakano et al., 2011; Draper et al., 2013; Robertson, Ward, and Jung, 2005). Thermotherapy is categorized as either superficial or deep, which is distinguished based on the targeted depth of tissue heating.

Superficial heating modalities are classified as increasing tissue temperature at a depth of 1-2cm. Examples of these modalities are dry and moist hot packs, paraffin baths, and warm whirlpools (Hawkes et al., 2013). Deep heating modalities cause a temperature increase in tissues 3-4cm deep. The two primary deep heating modalities include ultrasound and diathermy (Knight



& Draper, 2013). Research supports diathermy as a more effective deep heating modality than ultrasound (Garrett et al., 2000), therefore, diathermy will be further investigated in the study.

Shortwave diathermy uses high-frequency (10-100 MHz) electromagnetic waves to heat tissues. It is applied using a pulsed mode, in which the wave current is interrupted, creating pulses. Pulsed Shortwave Diathermy (PSWD) can trigger both thermal and non-thermal effects. However, activating thermal effects causes a rise in tissue temperature, which penetrates at a depth of about 3-5cm (Speed, 2000). This theory was supported by Peres et al. (2002) who reported that PSWD increases tissue flexibility in healthy college students when coupled with static stretching. When tissue flexibility is increased, it can stimulate an improvement in range of motion (ROM) (Nakano et al., 2012; Knight et al., 2001).

Like thermotherapy, research supports manual therapy as an effective treatment to treat and manage musculoskeletal conditions (AAOMPT, 2011, pg. 33; Sefton et al., 2010; Goats, 1994; Brummit, 2008; Pornratshance et al., 2005). Manual therapy can be applied in a variety of ways, with instrument assisted soft tissue mobilization (IASTM) being a type of manual therapy technique. Instrument assisted soft tissue mobilization is described as applying manual forces to generate changes in the myofascia, allowing for elongation of shortened structures (Godges, 2003). It is hypothesized that IASTM triggers a decrease in restriction of a muscle, fascia, or collagen, thus promoting normal joint movement (van den Dolder, 2003).

Over the past several years, a variety of instruments have been manufactured to apply IASTM techniques in a way that is not only safe for the clinician to utilize, but also beneficial for the patient. The AcuForce® 7.0 is one instrument designed for IASTM. However, what makes this instrument unique is the design. John G. Louis of AcuForce® International, Inc. had the goal of incorporating multiple treatment methods in one tool, such as trigger point release, friction

massage, effleurage, and muscle stripping (Louis, patent 1). Aside from its complex design, Louis reports that making the instrument weighted allows for constant pressure to be applied during treatments. By doing so, the clinician can give a treatment that is both safe to apply and safe for the patient to receive.

There are multiple studies describing the benefits of thermotherapy and manual therapy, and resources supporting the use of them combined (Draper et al., 2014; Robertson et al., 2005; Draper et al., 1995; Huang et al., 2010; Mosler et al., 2005). However, there is only one known study that compared thermotherapy to manual therapy. Dzedzic et al. (2005) conducted a randomized control trial that investigated whether adding manual therapy or pulsed shortwave diathermy (PSWD) to advice and exercise was more effective than advice and exercise alone in patients with nonspecific neck disorders. In conclusion, the researchers were unable to identify additional benefits when either IASTM or diathermy was used with advice and exercise to treat nonspecific neck pain. To date, there is no additional research that has investigated the differences between IASTM and diathermy. More specifically, there is no research that compares the two treatments and their effects on ROM.

### **Purpose of the Study**

The purpose of this study was to compare the effects of thermotherapy to those of manual therapy for improving hamstring flexibility, in which knee range of motion (ROM) was measured. Thermotherapy was applied using pulsed shortwave diathermy (PSWD), and instrument assisted soft tissue mobilization (IASTM) was utilized for manual therapy. Additionally, the subjects completed a post-intervention questionnaire to determine any differences in patient comfort between the two groups.

## **Research Questions**

1. Will IASTM, using the AcuForce<sup>®</sup> 7.0, create greater hamstring flexibility than diathermy?
2. Will there be an increase in ROM of the knee after the intervention of either IASTM or diathermy on the hamstring?
3. Which treatment will create greater perceived patient comfort during the intervention?

## **Definition of Terms**

Thermotherapy- the therapeutic use of heat; the application of a device or substance with a temperature greater than body temperature, thus causing heat to pass from the thermotherapy device to the body (Knight & Draper, 2013)

Diathermy- a modality that uses high-frequency electromagnetic waves to heat deep tissues (Knight & Draper, 2013)

Pulsed Shortwave Diathermy- transmits a series of high-frequency (10-100MHz) electromagnetic trains of waves to produce nonthermal and thermal effects in deep tissues (Knight & Draper, 2013)

Thermal- effects that cause an increase in tissue temperature (Starkey, 2004)

Pulse Duration (width)- the on-time; time required for each pulse to complete its cycle (Knight & Draper, 2013)

Pulse Rate- number of pulses delivered per second; also known as pulse repetition rate (Knight & Draper, 2013)

Power (Intensity)- the power delivered from the machine; a function of both pulse width and pulse frequency (Knight & Draper, 2013)

Manual Therapy- A specialized area of physical therapy for the management of musculoskeletal conditions, based on clinical reasoning, using highly specific manual techniques and therapeutic exercises (AAOMPT, 2011)

Instrument-Assisted Soft Tissue Mobilization (IASTM)- application of specific and progressive manual forces with the intent of promoting changes in the myofascia, allowing for elongation of shortened structures (Godges et al., 2003).

Range of Motion- mobility of a joint as determined by the surrounding soft tissue (Starkey, 2004)

### **Importance of the Study**

Increasing ROM is a goal that clinicians aim to accomplish to prevent and rehabilitate injuries. Two modalities used clinically to improve ROM are thermotherapy using PSWD and manual therapy using IASTM. Both treatments have been supported in research to have significant effects on ROM (Draper et al., 2014; Robertson et al., 2005; Draper et al., 1995; Huang et al., 2010; Mosler et al., 2005). However, there is limited research comparing the effects of IASTM and diathermy on the improvement of ROM. The benefits of IASTM are that it usually requires a shorter treatment duration, it is easily accessible for the clinician, and it is also a safe treatment for a variety of cases (Burke et al., 2007; Hammer, 2008; Baker et al., 2013). Compared to IASTM, diathermy has more contraindications for its use, it is a more expensive modality, and there is misconstrued information on how to use it. The results of this study will be important in determining which type of treatment is more effective to improving ROM in the clinical setting.

### **Limitations**

1. The subject population was not specific to an athletic population.

2. Only a Pulsed Shortwave Diathermy (PSWD) was used, and not Continuous Shortwave Diathermy (CSWD) due to PSWD being the accessible diathermy modality at the site where the research was conducted.
3. All subjects who received their designated treatments were treated with identical settings, which can potentially create false results when compared to individualized treatments.
4. The treatments utilized are commonly applied to patients with an injury, such as a muscle strain. For the study, subjects were healthy with tight hamstrings.

### **Delimitations**

1. Subjects consisted of male volunteers, with ages ranging from 18-50 years.
2. All subjects were identified as having tight hamstrings if hip flexion ROM was less than 90 degrees with the knee straight, measured with a goniometer.
3. Subjects did not have any hamstring, hip, or back injuries within the past 4 months.
4. All subjects in the diathermy treatment group received a 20 minute intervention, with a frequency setting of 27.12 MHz, pulse rate of 800pps, and pulse duration of 400 $\mu$ s, in theory achieving vigorous heating.
5. All subjects in the IASTM treatment group received a 7 minute intervention, using clinician hands for a 1 minute effleurage massage, using the middle section of the AcuForce<sup>®</sup> 7.0 for a 4 minute petrissage massage, and using the flat, billed section for a 2 minutes of muscle stripping.

## **CHAPTER 2. REVIEW OF LITERATURE**

The purpose of this study was to compare the effects of thermotherapy to those of manual therapy for improving hamstring flexibility, in which knee range of motion (ROM) was measured. Thermotherapy was applied using pulsed shortwave diathermy (PSWD), and instrument assisted soft tissue mobilization (IASTM) was utilized for manual therapy. Additionally, the subjects completed a post-intervention questionnaire to determine any differences in patient comfort between the two groups. The study was guided by the following questions: Will IASTM, using the AcuForce<sup>®</sup> 7.0, create greater hamstring flexibility than PSWD? Will there be an increase in knee extension ROM after the intervention of either PSWD or IASTM? Which treatment will create greater perceived patient comfort during the intervention? The review of the literature is organized into the following areas: Thermotherapy, Manual Therapy, Instrument Assisted Soft Tissue Mobilization, and AcuForce<sup>®</sup> 7.0.

### **Thermotherapy**

As explained by Knight and Draper (2013), thermotherapy is the use of a modality to increase tissue temperature. Upon application, heat passes from the device to the body through four transfer methods: conduction (direct contact), convection (fluid or air passing over the surface), radiation (through rays, waves, or particles), or conversion (a form of energy converted to heat within the body). Studies suggest therapeutic effects cannot happen unless the tissue reaches a temperature to between 40°C and 45°C (Giombini et al., 2007; Johns, 2002). However, other literature discusses temperature increases of 1, 2, 3, or 4°C from baseline, and the physiological effects at each temperature increase (Draper et al., 2013; Hawkes et al., 2013; Peres et al., 2002; Draper et al., 1995). The amount of increase in tissue temperature can be categorized as mild, moderate, or vigorous heating. Mild heating is a tissue temperature increase

of 1°C, which increases the metabolic rate of the heated tissue (Hawkes et al., 2013; Draper et al., 2013). Moderate heating is defined as an increased temperature of 2-3°C. At this increased temperature, a greater increase in metabolic rate, increased circulation, decreased pain, and decreased muscle spasm occurs. This increased circulation causes the heat to disperse over a wider surface area (Hawkes et al., 2013; Draper et al., 2013). Lastly, vigorous heating is described as a temperature increase of 4°C and greater (Hawkes et al., 2013; Draper et al., 2013). With vigorous heating, not only do metabolic and circulatory rates become greater, but also tissue stiffness lessens. The desired outcomes of the specific tissue temperature increases should be considered when making clinical decisions.

Due to the physiological responses of increased tissue temperature, thermotherapy is commonly used to relieve pain and stiffness, treat contractures, and accelerate inflammatory responses (Tepperman and Devlin, 1986). In addition, outcomes reported by Nakano et al. (2011) support thermotherapy as an adjunct treatment to increase the effects of stretching. This is due to the increase in tissue temperature, which increases elasticity in Type I collagen. Moreover, increased tissue temperature increases blood flow to the muscle, thereby reducing muscle spasm (Portillo-Soto, 2014; Hendricson et al., 1984). Therefore, thermotherapy can contribute to increases in ROM when coupled with stretching (Houghton et al., 2010; Starkey, 2004; Knight & Draper, 2013; Zabel, 2015). Through research, the physiological responses from thermotherapy are shown to be effective, supporting the use of it in the clinical setting.

### ***Superficial vs. Deep Heating***

Thermotherapy can be identified as either superficial or deep, which is based upon the depth of heating on the targeted tissue. Modalities that cause an increase in tissue temperature at a depth of 1-2cm are classified as superficial thermotherapy (Knight & Draper, 2013). Examples

of superficial heating modalities include dry and moist hot packs, paraffin baths, and warm whirlpools (Hawkes et al., 2013). Among superficial heating modalities, moist hot packs are the most commonly used in the clinical setting (Halvorson, 1990; Draper et al., 1998; Lehmann, 1978). However, Hendricson et al. (1984) examined the effects of superficial heating on hip range of motion with a dry heating modality. The study consisted of 30 healthy individuals randomized into three groups (superficial heat alone, superficial heat with stretching, and stretching alone), with five men and five women in each group. Prior to the intervention, baseline ROM for hip flexion, external rotation, and abduction ROM were measured. Range of motion measurements were collected at the conclusion of the intervention and 30 minutes post-intervention. For the subjects receiving the superficial heat intervention, with or without stretching, an electric heating pad was applied to the medial and posterior thigh for 20 minutes. The results indicated that utilizing heat prior to stretching significantly increased ROM both immediately and 30 minutes post-intervention ( $p < 0.001$ ).

While superficial heating shows promising results in regards to ROM, deep heating modalities target deeper tissues which could further increase ROM. Knight and Draper (2013) classified deep thermotherapy as a modality that creates a tissue temperature increase at a depth of 3-4cm. The two primary deep heating modalities are ultrasound and diathermy. Ultrasound is the use of high frequency, inaudible, acoustic waves to produce thermal physiologic effects (Knight & Draper, 2013; Nakano et al., 2011; Draper et al., 1995). To target deep tissues at a depth of 3-5cm, a frequency of 1 MHz should be used, while a frequency of 3 MHz should be used to target superficial tissues of 1-2cm deep (Speed, 2000). Thermal effects of ultrasound are attained when the frequency is set at a continuous duration, meaning there is no interruption in



the sound waves transmitted during treatment. Pulsed duration of ultrasound will create non-thermal effects, by creating intermittent sound waves during treatment (Speed, 2000).

In addition to ultrasound, diathermy is well known to have a significant role in promoting thermal effects. Ultrasound and diathermy are both utilized in the clinical setting. However, there is controversy on which is more effective. Garrett et al. (2000) compared the difference in muscle temperature after a 20 minute application of pulsed shortwave diathermy (PSWD) and a 20 minute application of ultrasound. The study consisted of 16 college students who were randomly assigned to one of two sequences: receiving diathermy before ultrasound or vice versa. The researchers used the Megapulse diathermy unit with a frequency of 27.12 MHz, and the Omnisound 3000C ultrasound unit with a 5 cm<sup>2</sup> transducer and a beam nonuniformity ratio of 1.4:1. To analyze the intramuscular temperature change, the researchers recorded the temperature of the triceps surae muscle group, via thermocouples, in degrees Celsius every minute. Participants received one condition of the treatment, rested until the tissue temperature reached baseline, and then received the other intervention.

The results indicated the diathermy treatment had a greater final tissue temperature increase in the triceps surae muscle than the ultrasound treatment ( $p < .0001$ ). In addition, temperature decay time for the ultrasound was  $14.88 \pm 4.70$  minutes to return to baseline, and temperature decay time for diathermy was  $38.50 \pm 6.61$  minutes to return to baseline. The temperature dropped 1°C in  $7.65 \pm 4.96$  minutes, 2°C in  $16.30 \pm 9.06$  minutes, and 3°C in  $22.8 \pm 9.2$  minutes following the diathermy treatment. Although both deep heating modalities heated the tissue at the same rate, diathermy affected a much larger area. This improved how much the heat in the tissue was retained and, therefore, the diathermy treatment had a greater temperature decay time. Having a longer temperature decay allows a clinician to stretch tissues longer. The study

supports the significant benefits of diathermy as a deep heating modality compared to ultrasound, due to its ability to target a larger area and improve temperature decay. Research supports the success of diathermy as a deep heating modality and its benefits as an adjunct treatment (Garrett et al., 2000; Draper et al., 2002; Nakano et al., 2012). Therefore, it is used in the clinical setting.

### ***Shortwave Diathermy***

As noted, diathermy creates tissue temperature increases that last for a significant amount of time post treatment (Garrett et al., 2000). One form of diathermy is short wave diathermy (SWD) (Appendix A), which increases tissue temperature with high-frequency (10-100 MHz) electromagnetic waves (Knight & Draper, 2013). The waves are passed into the spiral copper coils that are in the drum of the diathermy unit, which cause a magnetic field around the body. That magnetic field induces eddy currents within the tissue, which then triggers oscillation of the water molecules, and the friction of the molecules triggers a thermal effect (Knight & Draper, 2013). Since muscle tissue has a higher water content than skin, tendon, and bone, it tends to respond better to SWD and have larger increases in tissue temperature (Knight & Draper, 2013).

In addition to an increase in tissue temperature, SWD causes a reduction in swelling, acceleration in the inflammatory process, and promotion of healing in tissues (Draper et al., 1999; Haralson, 1988; Balogun, 1988; Goats, 1989). Therefore, the indications of SWD typically include: pain, subacute and chronic inflammatory conditions, decreased ROM, muscle spasms, swelling, and healing (Houghton et al., 2010; Starkey, 2004; Knight & Draper, 2013; Zabel, 2015). Although multiple benefits occur, there are contraindications of diathermy that clinicians need to consider before use. Contraindications include the following: pregnancy, malignant tumors, pacemakers, external metal such as jewelry, treatment over the eyes and gonads, acute injuries where increasing temperature is inappropriate, fever, and infections

(Zabel, 2015; Meshram et al., 2015; Shah et al., 2007; Shields et al., 2002; Shields et al., 2004; Starkey, 2004; Knight & Draper, 2013; Houghton et al., 2010).

Controversy exists as to whether metal is a contraindication for SWD. Some literature states that SWD should not be used on patients with implanted metal due to the risk internal thermal burning (Starkey, 2004; Knight & Draper, 2013; Zabel, 2015). However, Shields et al. (2004) explained that pulsed shortwave diathermy (PSWD), when utilized for non-thermal effects, would decrease the risk of burning since there is no change in temperature sensation. Nonetheless, PSWD would be a risk if the clinician was trying to target thermal effects.

Two case series support the use of PSWD and manual therapy to achieve an increase in ROM of particular joints with metal implants (Seiger and Draper, 2006; Draper, 2014). Seiger and Draper (2006) analyzed four patients that had metal implants from previous injuries, and have had failed improvements from physical therapy. The PSWD setting was set at 27.12 MHz, 400 microseconds, 800 pps, and 48W for 20 minutes, which are the parameters for a 4°C tissue temperature increase (Knight and Draper, 2013). Similarly, Draper (2014) analyzed the cases of six patients who had metal implants from elbow injuries and needed improvements in ROM. The PSWD setting was also set to achieve a 4°C tissue temperature increase. Both Seiger and Draper (2006) and Draper (2014) revealed increases in ROM amongst the subjects when given PSWD without adverse effects of having metal implants.

In conclusion, the studies support the use of PSWD and manual therapy to achieve increased ROM, regardless if implanted metal is present or not. Precautions that clinicians have to consider before applying SWD include the amount of the patient's perspiration formed from the heat therapy, the amount of adipose tissue over the treatment area, and the appropriate clinician distance away from the SWD to limit the overexposure to radiation (Shah et al., 2007;

Starkey, 2004; Shields et al., 2004; Zabel, 2015). Being mindful to the indications, contraindications and precautions, clinicians can provide effective treatments with PSWD.

According to modality textbooks, SWD has a common frequency of 27.12 MHz, and the following power settings are set for 1°C, 2°C, and 4°C temperature increases, respectively: 12W, 24W, and 48W (Michlovitz et al., 2012; Bricknell & Watson, 1995; Knight & Draper, 2013). The power, a function of pulse width (100-400µs), and pulse rate (400 or 800pps), influences how much of a tissue temperature increase is produced. The longer the pulse width and the higher the pulse rate, the greater the power. The following table highlights the appropriate settings for the desired temperature increases (Starkey, 2004; Knight & Draper, 2013).

Table 1

*Pulsed shortwave diathermy parameters and the corresponding temperature increases*

Temperature increase	Pulse width (µs)	Pulse rate (pps)
1°C	100µs	400 or 800pps
2°C	200µs	400 or 800pps
4°C	400µs	800pps

Like ultrasound, SWD can be administered as continuous or pulsed (Knight & Draper, 2013). Continuous shortwave diathermy (CSWD) is administered with a continuous current, meaning that the tissue is constantly receiving treatment. Contrary to CSWD, pulsed shortwave diathermy (PSWD) is dispensed by regularly interrupted waves, and can trigger both thermal and non-thermal effects. Activating thermal effects causes a rise in tissue temperature, which penetrates to a depth of about 3-5cm (Knight & Draper, 2013). There is controversy on which SWD mode is more effective. Teslim et al. (2013) conducted a pretest and posttest study that compared the effects of CSWD and PSWD in the management of chronic knee osteoarthritis. The study consisted of 24 subjects diagnosed with knee osteoarthritis treated at an outpatient

physiotherapy clinic. Subjects were randomly selected into one of the two groups via balloting, and were blinded to the group allocation. During the intervention, all subjects were seated in a chair while a researcher applied one diathermy electrode on the medial side of the knee joint and one electrode on the lateral side. The subjects in group one received 20 minutes of CSWD while group two received 20 minutes of PSWD. The treatment was applied twice a week for four weeks. In addition, the researchers assessed and recorded pain intensity and joint range of motion before and after each treatment (Teslim et al. 2013). The results revealed significantly more decreased pain and increased knee flexion with subjects who received CSWD compared to PSWD ( $p < .001$ ). Although Teslim et al. (2013) demonstrated positive outcomes with CSWD, textbooks (Knight & Draper, 2013; Starkey, 2004) are recommending that the continuous current heats too rapidly, which causes discomfort and is therefore not used as much in the clinical setting as PSWD (Knight & Draper, 2013).

In order to examine the change in temperature rise and decay in muscle during PSWD treatment, Draper et al. (1999) used a Megapulse diathermy unit on 12 volunteer college students. The diathermy drum was placed over the triceps surae muscle, and directly over the thermistor inserted in the muscle to measure temperature change. The treatment time was 20 minutes at the following settings: 800 bursts per second, 400  $\mu$ second burst duration, and an average root mean square output of 48W. The researchers collected temperature measurements at baseline, 5, 10, 15, and 20 minute marks during the intervention; and 5 and 10 minutes after the intervention. The results revealed a linear temperature increase for 15 minutes, followed by a decrease (Draper et al., 1999). Overall, the tissue temperature was constantly above baseline ( $p = .001$ ). The results were the following:

Table 2

*Results of study from Draper et al. (1999)*

Time	Average Temperature
5 minutes	1.36 ± 0.90°C
10 minutes	2.87 ± 1.44°C
15 minutes	3.78 ± 1.19°C
20 minutes	3.49 ± 1.13°C
Temperature decay (10 minutes)	1.78 ± 0.69°C

Therefore, the authors concluded there were significant thermal effects from PSWD treatment. With the settings of the diathermy in the study, the researchers were able to reach a degree of vigorous heating (4°C above baseline). The targeted area, at this rate, experienced increases in metabolic and circulatory rates, and decreased in stiffness, in theory (Hawkes et al., 2013; Draper et al., 2013). Thus, the previous studies support the use of pulsed shortwave diathermy as an effective adjunct when the goal is to increase ROM.

### ***Effects of PSWD on ROM***

As previously explained, thermotherapy is commonly used to enhance the effects of stretching due to the increase in tissue temperature, which increases elasticity in Type I collagen (Nakano et al., 2011). Draper et al. (2002) examined the use of PSWD with stretching, and its influence on hamstring ROM compared to stretching alone. The subjects consisted of 30 college student volunteers who received one of the three conditions: diathermy and stretching, sham diathermy and stretching, and control. Subjects in the diathermy and stretching group laid prone on a treatment table and had diathermy applied to the distal hamstring for 15 minutes, with a setting of 700 pulses per second with an average pulse width of 95 µsec. In the sham and

diathermy group, subjects laid prone with the diathermy rested on their hamstring. The researchers did not describe the sham diathermy settings other than it was set up to not produce heating effects. The subjects in the control group laid prone on the table for 15 minutes. Immediately following, the subjects in the diathermy and stretching as well as the sham diathermy and stretching groups, stretched three times for 30 seconds.

While the initial screening of straight leg hip flexion ROM was collected using a goniometer, hamstring ROM measurements were taken pre- and post-treatment using a sit-and-reach box. The results were not statistically different, however, all subjects significantly increased their hamstring ROM over the treatment period ( $p = .001$ ) (Draper et al., 2002). Overall, subjects in the diathermy and stretching and sham diathermy and stretching groups had larger increases in ROM than the control group. According to these results, diathermy may provide improvements in ROM when compared to stretching alone; however, the gains are not significant to support diathermy as a necessary adjunct treatment for significant gains in flexibility when compared to stretching alone.

Potential reasons for the lack of significance in the previous study include: possible uninfluential length of stretching time (3 times 30 seconds), and the pre and post intervention method of ROM measurement (sit and reach test). Therefore, Draper et al. (2004) conducted a study to address such limitations to determine whether PSD is significant in improving hamstring flexibility. The subjects consisted of 30 college students diagnosed with tight hamstrings ( $<160^\circ$  of knee extension while the hip is in  $90^\circ$  of hip flexion). After baseline measurements were taken using a goniometer, they were randomly placed in one of the three groups: diathermy and stretch, sham diathermy and stretch, and control. Subjects in the diathermy and sham diathermy groups received 1 treatment a day for 5 consecutive days, and all

subjects were measured before and after each treatment session, along with 72 hours after their last treatment.

For subjects in the diathermy and stretch group, the researchers used a Megapulse diathermy unit with the following settings: frequency set at 27.12 MHz, pulse duration set at 400  $\mu$ sec, and pulse rate set at 800 pps. The subjects laid prone while receiving treatment over the distal hamstring, just superior to the popliteal fossa of the knee. After 10 minutes, the patients laid supine and the treated hamstring was placed in a straight leg hip flexion stretch for 10 minutes; the position was maintained using a pulley and weight system to support the leg. The diathermy treatment was then reapplied to the hamstring for the first 5 minutes of the stretch. For subjects in the sham diathermy and stretch group, the same patient positioning protocol was followed, except the diathermy treatment was a sham. The sham diathermy parameters were not explained in the study. However, it was noted from the researcher that a little bit of superficial heat was given during both diathermy treatments and, therefore, blinded subjects to which group they were in. Subjects in the control group remained supine for 20 minutes.

The results revealed the subjects in the diathermy and stretch group had ROM improvements that were significantly greater than the other two groups. There was not a p-value was given in the study. The average increases in ROM were the following after 5 days of treatment:  $15.8^{\circ} \pm 2.2^{\circ}$  for the diathermy and stretch group,  $5.2^{\circ} \pm 2.2^{\circ}$  for the sham and diathermy group, and  $-0.3^{\circ} \pm 2.2^{\circ}$  for the control group. In addition, the researchers discovered that less ROM was lost 72 hours after the last treatment session in the subjects receiving diathermy and stretch, when compared to the sham diathermy and stretch and control groups (lost  $1.9^{\circ} \pm 2.2^{\circ}$ , lost  $3.0^{\circ} \pm 2.2^{\circ}$ , and lost  $-0.4^{\circ} \pm 2.2^{\circ}$  respectively). The study refutes Draper et al. (2002), who found no significant increases of ROM with the application of diathermy.



Similar to the previous study, Robertson, Ward, and Jung (2005) compared PSWD to a moist hot pack, a superficial heating modality, for differences in ROM. The researchers were testing whether superficial or deep heating had a greater impact on the extensibility of the calf muscle. The study consisted of 24 students who all received three different interventions: deep heating (PSWD), superficial heating (moist hot pack), and no heating. The interventions were performed at least 36 hours apart to decrease any carryover effects. Dorsiflexion ROM measurements were assessed prior to and after the interventions. The results indicated that both heat applications were more effective in improving dorsiflexion ROM than the control. However, the PSWD statistically increased ROM greater than the moist hot pack ( $p=.015$ ). Therefore, it was concluded that the application of diathermy was effective in increasing ROM.

The previous studies support the use of diathermy in improving ROM (Nakano et al., 2011; Draper et al., 2002; Draper et al., 2004; Robertson, Ward and Jung, 2005). However, there is still conflicting results as to whether diathermy provides significant improvements (Draper et al., 2002). Multiple factors may influence the inconsistency in research. First, the diathermy treatment durations ranged from 15 minutes in the Draper et al. (2004) and Robertson, Ward, and Jung (2005) studies to 20 minutes in the Draper et al. (2002) study. Nakano et al. (2011) reported reviewing treatment durations ranging from 5 to 20 minutes during their systemic review. Second, diathermy treatment parameters were inconsistent, with one study using 700 pps and a pulse width of 95  $\mu$ sec (Draper et al., 2002), and another not providing the parameters used (Robertson, Ward, and Jung, 2005). Third, stretching durations varied from 30 seconds to 10 minutes (Draper et al., 2002) to 20 minutes (Draper et al., 2004). And last, the methods of measuring ROM were different throughout the studies, such as the sit-and-reach test (Draper et al., 2002) to static stretching (Nakano et al., 2011; Draper et al., 2004). In conclusion, further

research is needed to develop a standard for treatment duration, treatment parameters, and stretching duration. By doing so, future research will potentially provide stronger evidence on the use of PSWD to gain ROM.

In addition to diathermy, other treatments can be utilized to improve ROM. The literature depicts the comparison of different thermotherapies, and also focuses on the combination of thermotherapy and other treatments (Draper et al., 2013; Garrett et al., 2000; Draper et al., 2004; Teslim et al., 2013; Nakano et al., 2012; Hanson et al., 2012; Cosgray et al., 2004). However, there is a lack of literature comparing differences in thermotherapy to other types of treatments and the impact on ROM. Of the limited studies, Dziejczak et al. (2005) conducted a randomized control trial that investigated whether adding manual therapy or pulsed shortwave diathermy (PSWD) to advice and exercise is more effective than advice and exercise alone in patients with nonspecific neck disorders. The advice given were messages focused to help cope with neck pain, such as: neck pain is common, temporary reduction of activity could help, and active people are more successful with coping.

The subjects consisted of 350 patients (18+ y/o) with nonspecific neck pain, diagnosed from a general practitioner and referred to a physical therapist. All subjects were randomly assigned to one of the three groups: advice and exercise alone, advice and exercise with manual therapy, or advice and exercise with PSWD. Physical therapists performed eight, 20 minute treatments over a six-week span, following the protocol for each respectable trial. Researchers measured the outcomes using the Northwick Park Neck Pain Questionnaire at baseline, six weeks, and six months. The authors concluded that neither manual therapy nor PSWD created any additional benefits when used with exercise to treat nonspecific neck pain. Therefore, the results of the study do not support adding thermotherapy or manual therapy to exercises to treat

neck pain. More specifically, the researchers did not include ROM as a variable when comparing the two types of treatments, so it is unknown how either treatment affected ROM.

### **Manual Therapy**

According to the American Academy of Orthopaedic Manual Physical Therapists (2011, pg. 33), manual therapy is defined as an intervention performed to treat and manage musculoskeletal conditions that use manual techniques. Other research states that manual therapy is used to assess, diagnose, and treat various symptoms and conditions in a non-surgical approach (Hoving et al., 2002; Farrell & Jensen, 1992; Fitzgerald et al., 1994; Jette & Delitto, 1997). Examples of manual therapy include myofascial release, trigger point release, instrument assisted soft tissue mobilization (IASTM), and massage therapy. These manual techniques are described as skilled hand movements that treat tissue inextensibility, decreased range of motion, muscle spasms, delayed-onset muscle soreness, immobile soft tissues and joints, pain, and soft tissue swelling, inflammation, and restriction (AAOMPT, 2011, pg. 33; Sefton et al., 2010; Goats, 1994; Brummit, 2008; Pornratshance et al., 2005). The positive outcomes of manual therapy are theorized to be a result of increased blood flow.

Similar to thermotherapy, manual therapy is applied to the tissue to increase blood flow. Portillo-Soto et al. (2014) compared two types of manual therapy, IASTM and massage therapy, by monitoring tissue temperature and blood flow. The study consisted of 28 subjects who were randomly assigned to either the Graston Technique<sup>®</sup> (IASTM) or massage therapy intervention. The treatment leg was also randomly assigned; the subjects' contralateral leg served as the control leg. Researchers measured skin temperatures immediately after treatment and at every five minutes post treatment for the next 60 minutes. Each subject received two treatments that were at least three days apart. The results indicated that massage increased skin temperature

significantly more than the Graston Technique<sup>®</sup> and control groups ( $p < 0.001$ ); temperature was also significantly increased at 5, 10, and 15 minutes ( $p < 0.001$ ). In addition, skin temperatures continued to increase until 25 minutes post treatment. However, both massage and the Graston Technique<sup>®</sup> significantly increased skin temperatures more than the control group. Therefore, Portillo-Soto et al. (2014) concluded that 10 minutes of soft tissue mobilization was effective in increasing skin temperature, both with and without the instrument being used. The researchers stated that a probable cause could be an increase in peripheral blood flow. Although the study supports the use of manual therapy to increase temperature and blood flow, it is inconclusive as to how deep in the tissue the increases were occurring. Therefore, further studies are recommended that measure the depth of temperature increases following manual therapy treatments.

Besides increasing skin blood flow, manual therapy has also been shown to treat abnormalities of connective tissue structures, such as shortened or immobile structures, which can contribute to pain and loss of motion within a joint (Threlkeld 1992). The external forces of the manual therapy produce changes in the length and mobility of the connective tissue through plastic deformation and break-down of connective tissue bundles, respectively. Aside from the clinical effectiveness manual therapy has on correcting musculoskeletal dysfunctions, there is also research indicating neurophysiological responses to manual therapy. Research suggests that a placebo effect contributes to the outcomes of manual therapy by minimizing negativity, amplifying realistic expectations, and drawing on patient preferences and past experience for evidence-based interventions (Bialosky et al., 2011). A non-systemic review performed by Bialosky et al. (2011) focused on the placebo effect caused by manual therapy, and concluded

that a placebo effect contributes to positive clinical outcomes of manual therapy for conditions of musculoskeletal pain.

To support the use of manual therapy, Bronfort et al. (2010) conducted an evidence report on the effectiveness of manual therapy to treat a variety of musculoskeletal and non-musculoskeletal conditions. The manual therapy techniques included spinal and extremity joint manipulation and mobilization, massage, and various soft tissue techniques. The researchers used systemic reviews of randomized clinical trials, evidence-based clinical guidelines and/or technology assessment reports, and all randomized clinical trials not included in the first three categories. The results of the review contained high level evidence that supported manual therapy to be effective in the treatment of various musculoskeletal conditions (Bronfort et al., 2010). Because of its effectiveness, manual therapy is a common type of treatment utilized in the clinical setting.

Furthermore, Zafar et al. (2015) supported the popularity of manual therapy by performing a cross-sectional study using a self-administered survey questionnaire to determine the importance and use of therapeutic massage. The researchers designed a 21 item questionnaire that included demographic and professional characteristics, the use of therapeutic massage, and perceived importance and confidence with the outcomes of treatment. Out of all of the respondents, 59% claimed therapeutic massage as an important aspect of treatment, and 17% found that therapeutic massage was very important. Therefore, the results support that therapeutic massage is frequently used in the clinical setting.

Manual therapy can be applied through various techniques, and are utilized to assess, diagnose, and treat a variety of conditions in a non-invasive manner. Its ability to increase blood flow, treat connective tissue structures, and trigger a placebo effect makes manual therapy a

beneficial treatment to treat pain, muscle spasms, and joint restrictions (Hoving et al., 2002; Farrell & Jensen, 1992; Fitzgerald et al., 1994; Jette & Delitto, 1997; AAOMPT, 2011, pg. 33; Sefton et al., 2010; Goats, 1994; Brummit, 2008; Pornratshance et al., 2005). Therefore, research supports that implement manual therapy is an adequate approach to treating limited ROM.

### ***Effects of Manual Therapy on ROM***

As noted, manual therapy is utilized to increase ROM. However, different theories exist in research as to how manual therapy affects ROM. One theory is through autogenic inhibition, or an activation of the golgi tendon organs (GTOs) to relax the muscle after a high level of tension (Robertson, 2008). A manual therapy method known as myofascial release is common in improving ROM by triggering autogenic inhibition. Additionally, myofascial release increases blood flow and reduces adhesions (Robertson, 2008).

To support the autogenic inhibition theory, Mohr et al. (2014) examined the change of passive hip flexion range of motion after six consecutive days of foam rolling (a form of myofascial release) and static stretching. The study consisted of 40 subjects randomly selected into the static stretching only group, foam roller and static stretching group, foam roller only group, or control group. Measurements were taken prior to treatment and immediately after treatment. The subjects receiving static stretching on their dominant leg were brought into a passive hamstring stretch for three sets of one minute duration, with 30 seconds in between each set. Subjects in the foam rolling intervention were instructed to follow the foam roll treatment protocol for three, one minute sets with 30 seconds in between each set. Those in the foam roller and stretching combined the same stretching and foam roller treatment protocol. The results revealed increases in passive hip flexion ROM for all subjects ( $p=.001$ ). However, there was a greater increase in the group that received both foam roller and static stretching ( $p=.04$ ). The

research supports the positive effects of self-myofascial release via foam roll and static stretching to improve joint ROM.

In addition to autogenic inhibition, another theory of manual therapy is its influence on decreasing pain perception due to decreased range of motion. A case study (Bell, 2008) that supports this theory was a 58 year-old active female, diagnosed with low back and sciatic pain. The patient received a total of six weekly, 45 minute manual therapy sessions for 10 weeks. Data was collected pre- and post-treatment weekly, and consisted of low back pain intensity determined by a visual analog scale (VAS), lower extremity functional assessment, overall pain level, and range of motion. On a 0 to 10 pain scale, the results revealed a decrease in the VAS score, starting at a pain intensity of about 4 and declining to zero. In addition, the patient was able to perform daily functions by the end of the study, some activities included squatting, lift objects off of the floor, prolonged standing/sitting, and getting in/out of the car. Aside from function, the study also revealed increases in range of motion. For example, knee-to-chest measurements started at 45° to approximately 120°. The results of the case study suggested massage therapy can decrease pain intensity, improve functionality, and increase hip range of motion.

Furthermore, Mosler et al. (2006) supported the theory that decreasing pain with manual therapy can improve ROM. The researchers reinforced the significant influence manual therapy has on athletic performance by investigating the effect of manual therapy on hip ROM, hip joint pain, and performance in water polo athletes. Sixteen male junior elite water polo athletes participated in a randomized crossover design, and were divided into either an intervention group or a control group; the patients crossed over four weeks later. The researchers measured active and passive hip internal and external rotation ROM in 90° hip flexion and 40° hip abduction

(Mosler et al., 2006). Performance was tested with vertical jump height and eggbeater kick endurance (kick performed to keep them afloat), and hip joint pain was determined by using the VAS pain scale. The interventions included various manual therapy techniques: trigger point release, friction massage, passive tissue tension, stretching, and hip distraction. The results revealed that there was a significant difference between the treatment and control group in passive internal and external rotation, along with total passive ROM. In addition, there were greater increases in active ROM in the treatment group compared to the control group. No significant differences existed in jump height ( $p=0.113$ ) and eggbeater endurance ( $p=0.116$ ) between the control and experimental group, but there were still increases in performance within each group. In conclusion, the research supported the claim that manual therapy can positively impact passive hip ROM, and have an effect on pain and possibly performance.

These results support the previously discussed case study (Bell, 2008) by conducting stronger evidence, as achieved with a larger group of subjects and its randomized crossover design. However, Mosler et al.'s (2006) study was unsuccessful in distinguishing a correlation between performance, ROM, and pain (performance/ROM  $r = -0.47$  to  $0.21$ ; pain/performance  $r = -0.2$  to  $0.02$ ; pain/ROM correlation not provided). Although the study results did not clarify the mechanisms of the improvements in performance, ROM, and pain, the study still supports the effectiveness of manual therapy. However, further research is needed to provide stronger support that decreasing pain perception is a vital contribution to improving ROM.

In addition to decreasing pain perception, research exists which supports the theory of manual therapy's neurological effects. The research, however, is inconclusive as to whether a change in reflex induced muscle activation or muscle stiffness is the reason for increased ROM (Chalmers, 2004; Enoka et al., 1980). Therefore, Huang et al. (2010) examined the effects of a



short duration massage on hip flexion ROM, passive hamstring tension, and EMG activity. The study consisted of 10 healthy and recreationally active women who underwent three interventions within one week, and were divided into either the control group, 10 second massage group, or 30 second massage group.

The intervention protocol included, in order: a 5 minute active warm-up, a 5 minute rest period, 3 ROM pre-test measures, another 5 minute rest period, the assigned intervention, and the measurements within 1 minute post-intervention. For subjects receiving massage treatments, friction massage was applied to the musculotendinous junction of the distal hamstring for either 10 or 30 seconds. Subjects in the control group were instructed to lay supine for 30 seconds instead of receiving a massage treatment. The results displayed significant increases in hip flexion ROM for both massage groups when compared to the control group. No p-values were reported, but alpha was set to  $p < 0.05$ ,  $ES = 0.73$ . In addition, a greater increase in ROM occurred in the 30 second massage group (7.2%) compared to the 10 second massage group (5.9%). It should be noted no numerical data was given, just the percentages. Throughout all three conditions (control, 10-second massage, and 30-second massage), post-massage hip ROM was significantly greater than the pre-massage measurement ( $p < 0.01$ ). While no significant changes occurred in passive muscle tension and EMG activity. Therefore, the study supports that an increase in ROM can occur with the application of short duration massage, without increasing passive muscle tension or EMG activity.

It should be reiterated that only 30 seconds of massage increased ROM, thus supporting the significant effects of manual therapy. However, with no changes in muscle tension and EMG activity, it is still debatable as to what the underlying neurological causes were for such improvements. Contributing factors that keep the topic debatable could include too short of an

intervention duration or not looking at the appropriate factors. Therefore, Sefton et al. (2011) further investigated the effects of therapeutic massage, applied to the neck and shoulders, and how the treatment influenced alpha-motor neuron pool excitability (neurons that initiate muscle contraction), EMG signal in the upper trapezius muscle, and cervical spine ROM. A cross-over design with repeated measures was used to conduct the study (Sefton et al., 2011). It consisted of 16 subjects, each receiving all three treatments on three separate days, one week apart. The three treatments consisted of the following: 1) therapeutic massage condition (TM), where subjects received 20 minutes of treatment, indicated as standard TM clinical intervention for neck and shoulder pain, 2) light touch condition (LT), where the massage therapist would place their hands in the same intervention areas as TM, but not apply massage strokes/pressure, and 3) control, in which subjects rested for 20 minutes on the table. The order of treatment was randomly assigned using a table.

During the study, the following was assessed: Hoffmann reflex of the flexor carpi radialis; EMG amplitude of the upper trapezius; and flexion, extension, lateral flexion, and rotation of the cervical spine. The results indicated TM significantly decreased flexor carpi radialis alpha-motor neuron pool excitability compared to LT ( $p < 0.001$ ) and the control ( $p < 0.001$ ). In addition, EMG signal amplitude in the upper trapezius muscle was significantly decreased following TM ( $p < 0.0001$ ), and cervical ROM was increased ( $p < 0.001$ ). Therefore, improvement in ROM could be a result of either decreases in pain perception or a decrease in neurological excitability.

Despite the previous results illustrated, there is still conflict on whether manual therapy is significant in increasing ROM. Various methods of manual therapy have been investigated to refute the skepticism of its influence on ROM. Godges et al. (2015) utilized soft tissue

mobilization (STM) combined with Proprioceptive Neuromuscular Facilitation (PNF) to investigate the effects on glenohumeral external rotation ROM and overhead reach. The study consisted of 20 subjects randomly assigned to the treatment or control group using a random number table. The same physical therapist, blinded to the subjects' assignment, measured external rotation and overhead reach before and after the intervention. The subjects in the treatment group underwent seven minutes of STM to the subscapularis, which is the muscle claimed to be responsible for limited external rotation at 45° of abduction. The STM treatment was a combination of manual digital pressure and slow, deep strokes. Immediately following the STM treatment, subjects performed the contract-relax PNF protocol, which was as follows: seven seconds of isometric internal rotation contraction against manual resistance, then active external rotation that was held for 15 seconds. This protocol was repeated five times. Afterwards, subjects performed five repetitions of a PNF diagonal pattern of flexion-abduction-external rotation against manual resistance (Godges et al., 2015).

The results revealed an immediate, significant increase in external rotation and overhead reach in the treatment group (95% CI, 12.5 °- 20.3°) when compared to the control group (95% CI, -0.2 °- 2.0 °) ( $p < 0.001$ ). The high level of evidence greatly supports the effect of manual therapy on ROM immediately following treatment. However, the researchers did not recognize underlying neurological factors to the treatment. More specifically, the researchers did not acknowledge that PNF stretching triggers autogenic inhibition, a concept explained previously in the Robertson (2008) study. Therefore, further investigation should be considered for an STM and PNF treatment.

Besides STM coupled with PNF, eccentric training and deep stripping massage (DSM) are ways to improve muscle flexibility to improve range of motion (Foreman et al., 2012).

However, limited research exists on the two treatments combined. Therefore, Forman et al. (2012) investigated whether there was an effect on hamstring strength and flexibility with DSM and eccentric resistance training. The subjects consisted of adult students 18-62 years old who had tight hamstrings, which was defined as presenting a  $\geq 15^\circ$  knee extension deficit when the hip was flexed at  $90^\circ$  with a relaxed ankle. Measurements of hamstring length and strength were taken prior to treatment and then again after treatment using a microFET3 digital muscle tester/inclinometer. To measure strength, the subject maximally contracted their hamstring by pushing against the machine for five seconds.

The subjects were divided into either the DSM with eccentric resistance group or DSM alone group (Forman et al., 2012). For the DSM with eccentric resistance group, subjects were positioned prone with a green TheraBand around the ankle of the leg with the tightest hamstring, or the dominant leg if both hamstrings were equally tight. Fifteen deep stripping massage strokes were applied from insertion to origin of the hamstring while the subject was resisting the TheraBand pulling the leg down from a flexed position to the table for a 10 second count. For the group receiving only DSM, 15 strokes were applied to the less tight hamstring, or the non-dominant leg if hamstrings were equally tight, while the patient was in a prone position. The results revealed a significantly greater increase in flexibility in the DSM with eccentric resistance group. The researchers did not provide a *p*-value, but set alpha to  $p < 0.05$ . They also revealed a non-significant increase in strength in the DSM with eccentric resistance group, compared to the DSM only group who showed a non-significant decrease.

Although the results showed increases in flexibility with the intervention, there are flaws that could be corrected to strengthen the level of evidence. The biggest flaw is the selection of leg for the different groups. Unlike Godges et al. (2015), which included treating the injured side

throughout all subjects, Foreman et al. (2012) had subjects in the DSM only group treated on the less tight hamstring, and the subjects in the DSM/stretch treated on the tighter hamstring. With a tighter hamstring, there is more ROM that needed to be gained compared to a hamstring that is not as tight. With more initial ROM, there is not as much ROM to gain or increase. Therefore, the results of the study could be altered because the treatment side and amount of hamstring tightness was not consistent. The studies conducted by Godges et al. (2015) and Foreman et al. (2012) support manual therapy has some effect on ROM. However, the studies are inconclusive as to whether these types of treatments are beneficial.

Aside from the treatments previously explained, dynamic STM is a relatively new technique. It is suggested to be a successful intervention in the clinic, but no evidence existed to statistically support that claim. Thus, Hopper et al. (2004) investigated the effects dynamic STM had on hamstring flexibility. The study consisted of 45 male volunteers, who were included in the study if they presented with a straight leg raise measured between 40° and 70° of straight leg hip flexion. After researchers measured the pre-treatment straight leg raise (SLR), subjects were randomly divided into a classic intervention, dynamic intervention, or a control group. The subjects in the classic intervention group received Swedish massage techniques on the hamstring muscle: five strokes of effleurage, kneading, picking up, and shaking for five minutes. For subjects in the dynamic intervention group, the researchers administered the same strokes as the classic intervention, but added passive movement into a hamstring lengthened position. The tight area was assessed, and if tightness was reduced, the researchers then moved onto the next dynamic technique. The next technique was the same positioning and intervention as the first, except the subjects were instructed to actively move their leg into the hamstring lengthened position. Lastly, the same intervention was given, except the subjects eccentrically resisted the

researchers' resistance while lengthening the hamstring. The subjects in the control group laid in a prone position on a table for five minutes (Hopper et al., 2004). The researchers took SLR measurements again after the intervention, in which they were blinded to the intervention given.

The results revealed a significant increase of hip flexion with subjects who received the dynamic intervention, as compared with the classic intervention and control groups ( $p=0.01$ ). In conclusion, these results support the use of massage to improve ROM. However, there is a possibility that results could have been skewed if women were also involved in the study. It should be noted this study and Foreman et al.'s (2012) study have similarities, including: patient positioning for the interventions, subject age, treatment groups, and positive outcomes. However, it is inconclusive to say which intervention is best.

### **Instrument Assisted Soft Tissue Mobilization**

Over the years, the practice of manual therapy has developed into a treatment that implements the use of instruments in order to perform the manual therapy intervention. Manual therapy can potentially cause some physical strain on the hands of the clinician. Therefore, instrument assisted soft tissue mobilization (IASTM) was created to ensure safety for the clinician (Burke et al., 2007; Hammer, 2008). Instrument assisted soft tissue mobilization is defined as a therapy technique that uses instruments to allow clinicians to detect tissue alterations and reach a greater tissue depth during application compared to using hands (Baker et al., 2013). This non-invasive technique allows the clinician to detect the area and treat the local dysfunctional soft tissue while applying pressure along muscle fibers (Baker et al., 2013; McCormack, 2012). Thus, IASTM provides a more effective treatment for patients and increased safety for clinicians (Baker et al., 2013). Studies have shown IASTM can generate an inflammatory response, which stimulates the breakdown of scar tissue, release of adhesions,

synthesis of new collagen, and connective tissue remodeling (Baker et al., 2013; Melham et al., 1998; Burke et al., 2007; Stow, 2011; Davidson et al., 1997). Moreover, IASTM can activate a regenerative response in soft tissue caused by capillary dysfunction, which then triggers fibroblast activation, macrophage mediated phagocytosis, and a local release of growth factors (McCormack, 2012; Davies et al., 2010). Because of the physiological effects, IASTM is an effective treatment for musculature and other soft tissue structures.

Treating soft tissue structures and musculature can positively affect ROM. To support this, Baker et al. (2013) reported a three-case series on the effects of IASTM on hamstring inflexibility. Hamstring inflexibility was defined through certain tests: ROM limitation on a standing flexion test, sit and reach test, passive and active straight leg hip flexion, and 90/90 active knee extension test. The patients consisted of three collegiate student athletes, 19-22 years old, presenting with hamstring tissue extensibility dysfunction. The researchers evaluated the following baseline measurements: active ROM, numerical rating scale (NRS) score for pain, and disablement in the physically active (DPA) scale. All patients received three IASTM treatments per week until discharged. The treatment included a five minute cycling warm-up, followed by an IASTM treatment for five minutes of each leg, then ended with 20 minutes of cryotherapy. Patients were eligible for discharge once active ROM and the DPA scale normalized. By the end of the second week of treatments, all patients displayed a minimal, clinically important difference with a six point decrease in the DPA scale score. In addition, all patients gained normal limits for straight leg hip flexion ROM, and there were significant changes in NRS scores for pain throughout the treatment duration. Although this study is a lower level of evidence, it demonstrated potential effects of IASTM on muscle inflexibility.

In addition, Baker et al.'s (2013) IASTM intervention was briefly described; the only description given was that the intervention was applied with passive hip flexion and extension. The lack of detail diminished the reliability and reproducibility of the study. Therefore, Laudner et al. (2014) further evaluated the benefits of IASTM on ROM by using a more common IASTM form on collegiate baseball players with decreased posterior shoulder ROM. The Graston Technique<sup>®</sup> was utilized, which is a form of IASTM that includes six uniquely designed stainless steel instruments to assess and treat soft tissue lesions.

The subjects consisted of 35 volunteer players who played at the NCAA Division I level. Using a blind, randomized design, the subjects were separated in two groups: one group receiving the Graston Technique<sup>®</sup> and the other receiving no intervention. The researchers took a single measurement for GH horizontal adduction and internal rotation before the intervention with a digital inclinometer. The researcher left the room immediately after they were done and another researcher entered the testing area to apply the treatment. This ensured the intervention was blinded to the researcher taking measurements. For the Graston Technique<sup>®</sup> treatment, subjects were instructed to lay prone on the treatment table, with their dominant throwing arm at a position of 90° shoulder abduction, 90° elbow flexion, and neutral rotation. While pulling excess skin towards the scapula, the researcher applied strokes with the Graston Technique<sup>®</sup> instrument GT 4 over the muscle fibers of the posterior deltoid, latissimus dorsi, teres major, teres minor, and infraspinatus. The research revealed the use of the Graston Technique<sup>®</sup> significantly increased glenohumeral horizontal adduction (+11.1° increase) and internal rotation ROM (+4.8° increase) in collegiate baseball players ( $p < 0.001$ ). Similar to Baker et al. (2013), Laudner et al. (2014) focused on a specific population, and therefore diminishing the



generalization of the study. However, the study provided a high level of evidence of the impact IASTM has on ROM.

Research exists on comparing IASTM techniques to different types of manual therapies, such as myofascial release techniques. As stated earlier, self-myofascial release with a foam roller is an effective manual therapy technique to improve ROM (Mohr, 2014). However, until Markovic (2015) compared IASTM and self-myofascial release on the improvement of ROM, no research had existed. Markovic (2015) compared the acute effects of foam rolling (a self-myofascial release) and Fascial Abrasion Technique (FAT) (a form of IASTM) on hip and knee ROM. Residual effects of the treatment were also evaluated 24 hours after application. Twenty regional level volunteer male soccer players partook in the study. The experiment took two sessions to conduct, separated by 24 hours. Before testing, all subjects performed a warm up that targeted the lower extremity. For the first session, the warm up was followed by measures of hip and knee ROM both before and after the intervention of a foam roll or IASTM. The second session consisted of only a warm up and range of motion measurements. The ROM was evaluated using supine passive knee flexion test and passive straight leg test, both common tests for ROM/muscle length (Markovic, 2015). The results revealed both treatments triggered increases in knee and hip range of motion, but FAT caused a greater effect (pre- to post-test gains in knee and hip ROM: 13.1° and 15.2°, or 10% and 19%). This supports the efficacy of IASTM, and how a short duration of a treatment can cause acute effects. The argument behind utilizing FAT instead of other forms of IASTM is the design of the instrument that allows for targeting deep tissue with less pressure. With less pressure, it decreases the risk of prolonging treatments due to discomfort and bruising of the patient. As research expands, new instruments

are emerging that allow effectiveness in treatment, and safety for not only for the patient, but the clinician as well.

### **AcuForce® 7.0**

The AcuForce® 7.0 (Appendix B) is one of the many instruments utilized for IASTM. Inventor John G. Louis of AcuForce® International, Inc. designed this instrument to allow a clinician to perform multiple treatment methods in one instrument. The AcuForce® 7.0 was created for various therapeutic techniques, such as trigger point, friction, effleurage, and muscle stripping (Louis, patent 1, 2001). The instrument was designed to have a long shaft that encompasses three sections. First, there is a small, rounded end intended to target trigger points. Second, the middle section consists of two circular prominences running parallel to each other; the two circular projections imitate an effleurage intervention. Lastly, the opposite end of the instrument is a flat, billed surface that is for the application of friction massage and muscle stripping techniques.

Specific to the AcuForce® 7.0, Louis ensures a constant pressure during intervention by making the instrument weighted. The use of hands, the Graston Technique®, and other forms of IASTM make it difficult to keep stamina to apply a quality treatment throughout multiple patients. This is particularly due to the fatigue and sometimes injury of the clinician caused by constant stress on the clinician's joints such as the hands, wrists, and elbows (Louis, patent 2). Therefore, the seven pound instrument allows for the clinician to apply the treatment safely with constant pressure. With a safer mechanism for the clinician, the intervention is hypothesized to be a more effective treatment. However, a minimal amount of research has been performed with the instrument. Therefore, it is not commonly seen in the clinical setting.

Of the limited research, Gibson et al. (2012) investigated the benefits of manual therapy and its changes in discomfort or knee extension torque output in patients with low back dysfunction (Gibson, PowerPoint presentation). Knee extension torque for patients with low back dysfunction was investigated because of previous research stating quadriceps inhibition often co-exists with low back dysfunction, but is unclear in research. For the manual therapy application, Gibson utilized the AcuForce<sup>®</sup> 7.0 on the quadratus lumborum muscle. The subjects consisted of 24 college athletes, both male and female who had been diagnosed with low back dysfunction with the use of the Oswestry Disability Index (ODI); the lower the ODI score, the less limitations with daily activity were present. There were two groups, case and control, that either had an ODI score of >10 or <10, respectively. Each subject had two days of testing, which were separated by 48 hours. The results revealed the AcuForce<sup>®</sup> 7.0 increased knee maximum voluntary torque output ( $p=0.043$ ). There was no significance between the groups ( $p=0.715$ ). Also, the majority of subjects reported feeling more flexible and relaxed. (Gibson, PowerPoint presentation). Although the study showed benefits of the AcuForce<sup>®</sup> 7.0, the results are not significant possibly due to the small sample size.

While the AcuForce<sup>®</sup> 7.0 increased knee maximum torque output, the effects on visumotor reaction time was unknown. Therefore, Cope et al. (2014) examined whether changes in visuomotor reaction time, or the relation of movement and visual perception by the brain, were a result of either the application of IASTM on suboccipital muscles or a result of gender of college athletes. Cope et al. (2014) utilized the seven-pound instrument to provide a 10 minute IASTM treatment that consisted of rolling and stripping techniques to the thoracic and lumbar erector spinae, and trigger point releases from the occiput to the superior margin of the scapulae. The researchers randomly assigned the subjects into the experimental group or the control group,

in which the control group completed the same visuomotor reaction time testing as the experimental group but without the treatment. The results revealed no significant differences between the experimental and control groups for all trials, thus not providing support for the use of the AcuForce<sup>®</sup> 7.0 on visuomotor reaction time. To date, there is little research utilizing the AcuForce<sup>®</sup> 7.0. More specifically, there is no known research that focuses on the AcuForce<sup>®</sup> 7.0 application and its impact on ROM.

In conclusion, pulsed shortwave diathermy (PSWD) and instrument assisted soft tissue mobilization (IASTM) trigger similar physiological effects that make increasing range of motion (ROM) attainable. Some of these physiological effects include increased circulation, reduced joint restrictions, and decreased pain, muscle spasms, and muscle soreness (Knight & Draper, 2013; AAOMPT, 2011, pg. 33; Sefton et al., 2010; Goats, 1994; Brummit, 2008; Pornratshance et al., 2005). Research exists that supports the use of Shortwave Diathermy to improve ROM. When compared to other thermotherapy modalities, such as ultrasound and a moist hot pack (superficial heat), it is indicated to apply significant thermal effects to achieve significant increases in ROM (Draper et al., 1999; Garret et al., 2000; Robertson et al., 2005). Alternatively, many variations of manual therapy have been shown to improve ROM, such as massage, soft tissue mobilization (STM) and proprioceptive neuromuscular facilitation (PNF), and the Graston Technique<sup>®</sup> (Robertson, 2008; Godges et al., 2015; Laudner et al., 2014).

Only one known study performed on the differences between PSWD and IASTM and the impact on non-specific neck pain exists. A randomized controlled trial was incorporated to determine whether manual therapy or PSWD could influence the success of advice and exercise compared to advice and exercise alone. The researchers utilized the Northwick Park Neck Pain Scale questionnaire (scale 0-100) for outcome measurements, and documented scores at six

weeks and six months of treatment. The results revealed increases throughout all groups with no significance between them. In conclusion, the results of the study indicate no added benefits with manual therapy or PSWD. Limited research exists comparing the effects of PSWD and IASTM on ROM, and the importance of ROM in the clinical setting (Bandy, Irion, & Briggler, 1997). Therefore, more research is needed to compare the effectiveness of PSWD and IASTM in improving ROM.

## **CHAPTER 3. METHODS**

The purpose of this study was to compare the effects of thermotherapy to those of manual therapy for improving hamstring flexibility, in which knee range of motion (ROM) was measured. Thermotherapy was applied using pulsed shortwave diathermy (PSWD), and instrument assisted soft tissue mobilization (IASTM) was utilized for manual therapy. Additionally, the subjects completed a post-intervention questionnaire to determine any differences in patient comfort between the two groups. The study was guided by the following questions: Will IASTM, using the AcuForce<sup>®</sup> 7.0, create greater hamstring flexibility than pulsed shortwave diathermy? Will there be an increase in ROM of the knee after the intervention of either pulsed shortwave diathermy or IASTM? Which treatment will create greater perceived patient comfort during the intervention? This chapter focuses on the following: experimental design, subjects, examiners, instrumentation, range of motion measurements, procedures, and data analysis.

### **Experimental Design**

The study was a randomized pretest-posttest experimental design. The independent variables were the two treatments (IASTM and stretch, and PSWD and stretch) and dependent variables were knee extension ROM, measured in degrees, and perceived patient comfort.

### **Subjects**

Twenty volunteer male subjects were recruited using a convenience sampling method. The subjects consisted of students, faculty, and staff from North Dakota State University (NDSU), ages ranged from 18-50 years and were recruited via NDSU email listserv. The inclusion criteria consisted of subjects presenting hamstring tightness, diagnosed as a subject having 40-70° of straight leg hip flexion ROM with the knee extended. The exclusion criteria

included: any hamstring, hip, or back injuries within the past 4 months; straight leg hip flexion ROM greater than 70° with the knee extended; any metal pins, plates, or screws in the measured femur; participation in a lower extremity flexibility program; any discomfort during the study the researchers deemed to be more than a normal sensation (gentle warmth, gentle stretch, etc.); or cardiopulmonary problems, such as dysrhythmias, hypertension, etc. (Hopper et al., 2005; Draper et al., 2002; Draper et al., 2004; Peres et al., 2002; Rosario & Foletto, 2013; Brunker et al., 2005). The amount of weekly recreational activity of each subject was determined from an activity focused questionnaire (Appendix D). The questionnaire was analyzed for trends throughout all subjects; however, it did not affect their eligibility for the study. By not having a specific physical activity level as an inclusion criteria, the study increased the generalization of the results rather than focusing on an athletic population. Prior to reporting, subjects were instructed to wear comfortable clothing, such as t-shirts and athletic shorts, throughout the entire study. In addition, subjects were instructed to not wear jewelry with metal or clothing that had metal on them, such as a zipper or metal buttons.

### **Instrumentation**

The instruments utilized for the treatments in this study were the Intelect® SWD100 (Chattanooga, DJO Global, Vista, CA) (Appendix A) for the PSWD treatment, and the AcuForce® 7.0 (Magister Corp., Medco, Chattanooga, TN) (Appendix B) for the soft tissue mobilization treatment. The Intelect® SWD100 was obtained through the North Dakota State University Advanced Athletic Training Program. The diathermy unit was calibrated by the company before it was shipped in July 2016. Only the examiner assigned to perform the PSWD treatment was allowed to control the PSWD to prevent damage to the instrument. The AcuForce® 7.0 was attained through the Valley City State University Athletic Training Room;

permission was given by the Head Athletic Trainer, Anna Bratsch, to use for the study. To measure ROM for baseline, pre- and post-test measurements, a goniometer (JAMAR, Medco, Tonawanda, NY) was used. To maintain proper subject positioning for goniometric measurements, a handmade apparatus was borrowed from previous studies (Nejo et al., 2014; Bates et al., 2016) (Appendix C). The apparatus composed of a strap that was attached to the wall and wrapped around the distal aspect of the thigh to maintain 90° of hip flexion while knee extension was measured.

### **Procedures**

The subjects reported to room 14 of the Bentson Bunker Fieldhouse on the first day of treatments at their assigned time; scheduled times were in 30 minute increments throughout the study, with two subjects reporting at each increment. However, the first day was in 40 minute increments to allow enough time for subject orientation of the study. Prior to baseline measurements, the investigator described the study to the subjects (inclusion and exclusion criteria, instrumentation, procedure, details on future report times, etc.). Once the study was explained and all questions were answered, the subjects signed a consent form, and had their straight leg hip flexion measured to determine inclusion. Straight leg hip flexion was measured using the following parameters: the fulcrum of the goniometer was placed over the greater trochanter, the stationary arm was parallel to the midline of the trunk, and the moving arm was parallel to the midline of the femur. Both legs were measured, and the leg with the least amount of ROM received the treatment; the other leg was used as the control variable. Both legs were tested once, and the leg with the least amount of range of motion received the treatment throughout the duration of the study.



Along with the consent form and ROM measurements, the subjects filled out the activity-focused questionnaire (Appendix D) prior to the study. The study was approved by the Institutional Review Board of North Dakota State University prior to investigation. For participating in the study, each subject received \$20 when they completed all sessions. To randomly assign subjects to a treatment group, each subject was assigned to a number. That number was written on a piece of paper, folded, and placed in a container. Using a drawing method, the subjects' numbers were alternately placed in one of the two experimental groups. Subjects were assigned to their group prior to arrival, and scheduled for their session depending on their assignment (one subject from each group at each time increment).

The examiners consisted of two NDSU Advanced Athletic Training graduate students of the NDSU Post-Professional Master of Science in Advanced Athletic Training Program. Both examiners were certified Athletic Trainers who had been educated on modalities and goniometric measuring. Examiner 2 was specifically assigned to provide all PSWD and IASTM treatments throughout the study. Examiner 1 was assigned to measure ROM of every subject and write down the measurements, regardless of the treatment group. This examiner was blind to the treatment received. Range of motion (ROM) measurements were taken before and after each treatment. Examiner 1 took pre- and post- intervention ROM measurements in Room 14, the research lab, of the NDSU Bentson Bunker Fieldhouse (BBF). All treatments took place in the NDSU BBF room 24, the classroom.

Examiner 1 measured straight leg hip flexion three times, and took the average measurement for data collection. After the inclusion measurements were taken, subjects were positioned supine on the table with their treatment leg positioned at 90° of hip flexion. This position was held by a handmade apparatus (Nejo et al., 2014; Bates et al., 2016) borrowed for

this study (Appendix C). For baseline, pre-, and post-test measurements, the goniometer fulcrum was placed over the lateral knee joint line. The stationary arm was lined up with the greater trochanter, and the moving arm was lined up with the lateral malleolus. All measurements were collected three times by Examiner 1 to ensure intrarater reliability.

Each subject received the intervention treatment three times a week for one week, with at least 24 hours in between each session. For subjects receiving PSWD, they were positioned prone with the PSWD applied to their tighter hamstring at the middle point of the muscle belly. A towel was draped over the hamstring prior to treatment to ensure there wasn't an increased risk of skin burning due to perspiration triggered from the heat. The following parameters were used for the 20 minute PSWD treatment: 800 bursts per second, 400 microsecond burst duration, 800 microsecond interburst interval, with an average root mean square output of 48W. The settings were selected based on previous studies and textbook recommendations, with a goal of reaching vigorous heating (4°C tissue temperature increase) within the hamstring muscle (Draper, 2014; Draper et al., 2004; Peres et al., 2002; Starkey, 2004; Knight & Draper, 2013).

For subjects receiving IASTM, patients were positioned prone with the knee extended and the foot hanging off of the table. Prior to the IASTM treatment, Examiner 2 applied emollient to the skin to reduce friction of the instrument on the skin. Using the AcuForce® 7.0, the strokes of the intervention were applied distal to proximal, targeting the entire hamstring muscle belly. The IASTM treatment lasted 7 minutes. For the first minute, the researcher used her hands to provide an effleurage massage. Then, the middle section of the AcuForce® 7.0 was used to provide a petrissage massage for four minutes. Finally, the flat, billed section of the AcuForce® 7.0 was used for two minutes of muscle stripping massage (Louis, J. G., personal communication, March 25, 2017). The petrissage massage and the muscle stripping massage

were applied to the entire hamstring muscle, distal to proximal, while attempting to keep similar pressure throughout both massages. Consistent patient feedback was given to determine if the pressure was too uncomfortable and needed to be adjusted.

All subjects had the tighter hamstring stretched three times for 30 seconds after their treatment was completed. Hamstring stretches were performed in a straight leg, hip flexed position. At the ten minute mark of the PSWD treatment, the examiner started the IASTM treatment on the subject assigned to the IASTM group. Immediately following the seven minute IASTM treatment, three sets of 30 seconds of stretching were applied. The IASTM subject then reported back to room 14 for post-intervention measurements. The examiner then returned to the PSWD subject and performed three sets of 30 seconds of stretching following that treatment. After stretching was complete, the PSWD subject reported back to room 14 for post-intervention measurements. Examiner 1 took three measurements, and took the average measurement for the post-treatment ROM.

All measurements were documented on paper during the intervention, and then transferred onto an Excel spreadsheet. Treatment sessions lasted about 25-30 minutes, except for the first and last days that lasted about 35-40 minutes due to extra paperwork. At the end of the two weeks, the subjects were given a questionnaire that asked their opinion about comfort for the treatment they received (Appendix E). To conclude the study, each subject received \$20 for participation.

### **Data Analysis**

A dependent t-test was performed to determine any differences between the ROM of the two groups and for differences in perceived patient comfort between groups. Data from the Patient Feedback Questionnaire (Appendix F) was coded for themes. An ANOVA was

performed with repeated measures to test for significant changes in range of motion throughout the three treatments. Data analysis was completed using SPSS Statistics 24 Software (SPSS Statistics, Version 24.0, Armonk, NY: IBM Corp.).

## **CHAPTER 4. RESULTS**

The purpose of this study was to compare the effects of thermotherapy to those of manual therapy for improving hamstring flexibility, in which knee range of motion (ROM) was measured. Thermotherapy was applied using pulsed shortwave diathermy (PSWD), and instrument assisted soft tissue mobilization (IASTM) was utilized for manual therapy. Additionally, the subjects completed a post-intervention questionnaire to determine any differences in patient comfort between the two groups. The study was guided by the following questions: Will IASTM, using the AcuForce<sup>®</sup> 7.0, create greater hamstring flexibility than diathermy? Will there be an increase in knee ROM after the intervention of either diathermy or IASTM? Which treatment will create greater perceived patient comfort during the intervention? This chapter focuses on the results of the study, and is organized into descriptive statistics, results, and summary of the results.

### **Descriptive Statistics**

Twenty male NDSU students, faculty and staff were screened prior to treatment for tight hamstrings, which was defined as straight leg hip flexion ROM between 40° and 70°. If subjects met the criteria, they were included in the study. All but one subject presented with ROM less than 70°, and therefore one subject was rejected from the study. That subject was then replaced with a subject who met the criteria for the study, thus fulfilling 20 subjects. All eligible subjects chose to participate; none of the subjects dropped out of the study. According to the activity questionnaire, 19 of 20 subjects reported to be physically active, averaging approximately 3-4 days a week of physical activity. The one subject reported not being physically active throughout the week, which was defined as no activity during the week. The subjects ranged from 18 to 50 years old, with the mean age of  $24.50 \pm 5.75$  years.

## Results

Using a dependent *t*-test, a statically significant increase in knee extension ROM with 90° hip flexion occurred in all subjects ( $p = 0.013$ ). Across all subjects, significant increases existed in ROM between daily pre- and post-measurements of knee extension ROM with 90° hip flexion (Day 1  $p < 0.001$ ; Day 2  $p = 0.025$ ; Day 3  $p < 0.001$ ); greater increases occurred between pre- and post-treatment measurements on Day 1 and Day 3 ( $p < 0.001$ ) than Day 2 ( $p = 0.025$ ). In the control leg, or the non-treatment leg, the average straight leg hip flexion ROM measurement throughout all subjects was  $64.15^\circ \pm 11.32^\circ$ .

Table 3

*Pre- and post-range of motion measurements (in degrees) of knee extension (with the hip flexed at 90°) throughout the three days of treatment*

	PSWD	IASTM	All Subjects
Baseline	$143.50^\circ \pm 8.49^\circ$	$154.17^\circ \pm 10.23^\circ$	$148.83^\circ \pm 10.66^\circ$
Day 1- Post Treatment	$147.13^\circ \pm 8.01^\circ$	$155.80^\circ \pm 9.45^\circ$	$151.47^\circ \pm 9.62^\circ$
Day 2- Pre Treatment	$149.47^\circ \pm 9.71^\circ$	$150.37^\circ \pm 13.20^\circ$	$149.92^\circ \pm 11.29^\circ$
Day 2- Post Treatment	$150.63^\circ \pm 7.06^\circ$	$153.53^\circ \pm 10.73^\circ$	$152.08^\circ \pm 8.97^\circ$
Day 3- Pre Treatment	$148.50^\circ \pm 7.61^\circ$	$154.77^\circ \pm 9.59^\circ$	$151.63^\circ \pm 9.02^\circ$
Day 3- Post Treatment	$152.30^\circ \pm 4.30^\circ$	$159.00^\circ \pm 7.45^\circ$	$155.65^\circ \pm 6.85^\circ$

For subjects receiving PSWD, ROM increased from  $143.50^\circ \pm 8.49^\circ$  to  $152.30^\circ \pm 4.30^\circ$ . This is an increase of  $8.20^\circ \pm 4.00^\circ$  per subject. In comparison, ROM increased from  $154.17^\circ \pm 10.23^\circ$  to  $159.00^\circ \pm 7.45^\circ$  for those who received IASTM treatment. This is an increase of  $4.80^\circ \pm 4.00^\circ$  per subject, about half the amount of ROM as the subjects in the PSWD group.

Using one-way ANOVA with repeated measures, the results showed no significant differences in ROM measurements between the PSWD and IASTM groups ( $p = 0.08$ ).

Mauchly's tests indicated the assumption of sphericity had been violated ( $\chi^2 (14) = 27.37, p = 0.018$ ); therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ( $\epsilon = .629$ ).

Interestingly, no statistically significant differences existed between groups for perceived patient comfort ( $p = 0.156$ ). The subjects rated their comfort by the following: 1= very uncomfortable, 2= slightly uncomfortable, 3= neutral, 4= slightly comfortable, 5= very comfortable. For subjects receiving the PSWD treatment, the rating was  $4.70 \pm 0.48$ . For subjects receiving the IASTM treatment, the rating was  $4.00 \pm 1.16$ . There were two subjects that reported their treatment was slightly uncomfortable, and those two subjects were in the IASTM group. In comparison, there were no subjects in the PSWD group that reported their treatment to be uncomfortable. Overall, 11 out of the 20 subjects reported their treatment to be very relaxing, seven of the subjects in the PSWD group, and four in the IASTM group.

Of the 20 subjects, 19 reported that they would receive their treatment again. More specifically, all IASTM subjects answered the question, and only nine answered from the PSWD group. In the PSWD group, seven of the subjects provided feedback as to why they would receive their treatment again; two subjects left the feedback section unanswered. Some of the comments included: "relaxing", "non-intrusive", "felt good and stretching after helped", "not at all uncomfortable", "a slight heating sensation", and "easy". In the IASTM group, nine of the subjects provided feedback, and had comments including: "I could feel progress", "it made my hamstring feel better", "my muscles felt relaxed, and it was calming", and "it helped with my soreness".

There was one subject in the IASTM group who marked "no" for receiving the treatment again, and one subject who failed to respond to the question on the questionnaire in the PSWD

group. The IASTM subject’s reason for not wanting to receive the treatment again was because he found previous treatment methods that he had experienced to be more effective and efficient; the subject did not specify the treatment methods he was referring. When asked for notable improvements, 5 subjects in the PSWD group reported “yes”, compared to the 8 subjects in the IASTM group. The improvements that were noted in the PSWD group were “more flexibility”, “more motion”, and “felt looser”. In the IASTM group, improvements included “more flexibility”, “felt looser”, and “decreased pain”. These results show a trend that PSWD and IASTM provide similar patient comfort. However, because of the small sample size, a strong conclusion cannot be drawn.

Table 4

*Perceived patient comfort between the two treatment groups*

Comfort Level	Number of Subjects PSWD	Number of Subjects IASTM
1= very uncomfortable	0	0
2= slightly uncomfortable	0	2
3= neutral	0	0
4= slightly relaxing	3	4
5= very relaxing	7	4
MEAN RATING	4.70 ± 0.48	4.00 ± 1.16

Table 5

*Patient Feedback Questionnaire results*

	PSWD Number of Subjects/ response	IASTM Number of Subjects/ response
Would you get that treatment again?	“yes” – 9 subjects “no” – 0 subjects (1 unanswered)	“yes” – 9 subjects “no” – 1 subject
Did you notice any improvements?	“yes” – 5 subjects “no” – 5 subjects	“yes” – 8 subjects “no” – 2 subjects



## **Summary of Results**

The results of the study indicated a statistically significant increase in knee extension range of motion (ROM) throughout all subjects over three days of treatment. However, there were no statistically significant differences in ROM increases between the PSWD and the IASTM treatment groups. In addition, the results revealed no statistically significant differences in perceived patient comfort between the PSWD and the IASTM treatment groups.

## **CHAPTER 5. DISCUSSION**

The purpose of this study was to compare the effects of thermotherapy to those of manual therapy for improving hamstring flexibility, in which knee range of motion (ROM) was measured. Thermotherapy was applied using pulsed shortwave diathermy (PSWD), and instrument assisted soft tissue mobilization (IASTM) was utilized for manual therapy. Additionally, the subjects completed a post-intervention questionnaire to determine any differences in patient comfort between the two groups. The study was guided by the following questions: Will IASTM, using the AcuForce<sup>®</sup> 7.0, create greater hamstring flexibility than PSWD? Will there be an increase in knee ROM after the intervention of either PSWD or IASTM? Which treatment will create greater perceived patient comfort during the intervention? This chapter focuses on a discussion of the results of the study, and is organized into the following: discussion, limitations of the study, recommendations for future research, and conclusion.

### **Discussion**

Increasing range of motion (ROM) is an important goal to obtain to prevent injury and regain normal muscle function (Bandy, Irion, & Briggler, 1997; Starkey 2004). This study focused on two types of treatments utilized to achieve increased ROM: pulsed shortwave diathermy and instrument assisted soft tissue mobilization. Pulsed shortwave diathermy (PSWD) and IASTM trigger similar physiological effects (Knight & Draper, 2013; AAOMPT, 2011, pg. 33; Sefton et al., 2010; Goats, 1994; Brummit, 2008; Pornratshance et al., 2005), but a minimal amount of research has compared the two modalities.

This study indicated significant increases in ROM throughout all subjects, but greater improvements in the PSWD group compared to the subjects in the IASTM group (Table 3). The

study, however, revealed no statistically significant differences between the two treatment groups ( $p = 0.08$ ) (Table 3). There is contradiction on the interpretation of the  $p$ -value, more specifically when to interpret what is statistically significant and what is not statistically significant (Dahiru, 2008). Although the results of this study reveal a difference between the two groups, there are factors that could have altered the  $p$ -value and influenced its statistical significance. These factors include the effect size, the size of the sample, and the spread of the data (Dahiru, 2008). Using an inappropriate index for measurement, having a large sample size, or having a large standard deviation could result in a lower  $p$ -value. To interpret research as substantial evidence, Dahiru (2008) suggests utilizing confidence interval (CI) more because it provides an estimation over hypothesis testing, more reliability in information, and it is invulnerable to type I error. By targeting these factors in future research, the statistical results may be different and could have significance to the research conducted.

Although the results were not statistically significant, about a 4° greater increase occurred in the PSWD group than the IASTM group. This could be clinically significant when considering a potential quicker recovery with a PSWD treatment following an injury that has temporarily limited ROM. A greater increase in ROM could also indicate more likely of a chance to prevent injury (Zachezewski, 1989). Aside from a quicker recovery and prevention, it could also imply a greater success with achieving the last few degrees of ROM that could be difficult to obtain after an injury. And with that, a patient could have improved performance in daily activity. Possible explanations for the slight changes in ROM could include greater tissue temperature, reduced muscle spasm, and greater patient comfort. Based on the results from the surveys, most subjects thought PSWD provided a relaxing, warm treatment, compared to IASTM that provided

discomfort for some. That discomfort could lead to increased muscle contraction and patient resentment from the treatment.

Throughout all subjects, a  $7.00^\circ \pm 4.00^\circ$  increase in ROM occurred from baseline to the concluding measurement (Table 3). The large improvement in ROM throughout the study suggests both treatments are able to trigger ROM increases comparable to the non-affected leg. The ability of subjects extending the knee farther when the hip was in at least  $90^\circ$  of flexion indicates that improvement. Even though the control leg was measured with a different patient position (straight leg hip flexion), the end goal of hamstring flexibility was the same. With straight leg hip flexion, the clinician was placing the hip in as much flexion as possible while the knee was already at its full extension. Regardless, the improvement in ROM throughout the study suggests a clinician is able to create approximate symmetry in both legs if the affected leg is to ever decrease in ROM due to a complication.

Numerous studies on PSWD use the protocol setting that validates a  $4^\circ$  increase within the tissue, which is described as vigorous heating (Draper, 2014; Draper et al., 2004; Peres et al., 2002; Garrett et al., 2000; Draper et al., 1999; Draper et al., 2013). Although this study did not specifically measure intramuscular temperature, the effects of this study are comparable to the results of previous studies that measure temperature. This corroborates a likelihood of a great enough increase to trigger physiological effects that are understood to be seen at a  $4^\circ$  increase, specifically increasing tissue extensibility (Draper, 2014; Draper et al., 2004; Peres et al., 2002; Garrett et al., 2000; Draper et al., 1999; Draper et al., 2013).

Aside from tissue temperature increases, a decreased tissue temperature decay rate has also been reported to occur with PSWD when compared to other heating modalities (Draper et al., 2013; Draper et al., 1999; Garrett et al., 2000). With a reduced temperature decay, clinicians

are given the opportunity to utilize the “stretching window” of heat therapy more effectively in order to obtain a greater ROM result. With that said, retaining the 4° temperature longer is a potential reason why the subjects of the PSWD group collectively achieved a greater gain in ROM (about  $8.20^{\circ} \pm 4.00^{\circ}$ ) than the subjects of the IASTM group (about  $4.80^{\circ} \pm 4.00^{\circ}$ ). No known research exists which investigates temperature changes with IASTM application. Portillo-Soto, et al. (2014) reported increases in skin temperature after a massage or Graston® Technique. However, the study did not look at temperature changes in the muscle.

In addition, decreased temperature decay could be a reason for the PSWD subjects maintaining greater ROM measurements than their baseline. On the 2<sup>nd</sup> and 3<sup>rd</sup> day of treatment, subjects in the PSWD group had at least a 5° pre-treatment ROM measurement greater their baseline ROM. However, the subjects in the IASTM group had a pre-treatment ROM measurement 4° lower than the baseline on day 2. A possible reasoning for this discovery was the amount of time between day 1 and day 2. Due to scheduling conflicts, the majority of the subjects had at least 48 hours in between day 1 and day 2 treatments. Thus, allowing time for patients to participate in unknown activities that could have hindered progress. On day 3, the IASTM pre-treatment ROM measurement was the same as the baseline ROM.

Instrument assisted soft tissue mobilization was utilized for the study to detect and treat tissue alterations that is safe for both patients and clinicians, while targeting a tissue depth greater than possible with hands (Baker et al., 2013; AAOMPT, 2011). The results of this study supports previous literature on the immediate effects of IASTM (Laudner, et al., 2014; Markovic, 2015; Kivlan et al., 2015). Similar to Laudner, et al.’s study, which showed a significant group-by-time relationship for shoulder ROM following IASTM compared to the control group ( $p < 0.001$ ), this study showed daily ROM increases of 1-5° after intervention.

Additionally, this study had similar results to Markovic (2015), which revealed significant group-by-time interaction throughout all subjects (Fascial Abrasion Technique group and foam roll group) for hip and knee ROM ( $p < 0.001$ ). But unlike this study, the IASTM treatment triggered greater gains in knee and hip ROM, both immediate and 24 hours later, when compared to the other treatment (immediate: 13.1°/15.2° increase and 6.6°/7.0° increase, respectively; 24-hours: 9°/10.1° increase and no gains from pre-test, respectively). Differences between this study and Markovic's (2015) study could be the differences in instruments used for the IASTM treatment.

Only a few studies with low levels of evidence analyzed changes in the effects of IASTM over a period of time greater than 24-48 hours (McCormack, 2012; Baker et al., 2013; Lee et al., 2016). The time period of the treatments ranged from 4 to 8 weeks, with treatments administered 2-3 times per week throughout the studies. All studies resulted in decreases in pain and significant increases in ROM and functionality with all subjects tested. If this study mimicked the length of time like previous studies, there could have been more of a similarity between IASTM and PSWD groups rather than a 4° difference.

The lack of statistical significance between PSWD and IASTM in this study is similar to the results of Dziedric et al. (2005). They investigated whether adding PSWD or manual therapy to exercises and advice would promote better results in non-specific neck pain than just exercises and advice alone. The results from Dziedric et al.'s (2005) study revealed adding PSWD or manual therapy contributed to greater decreases in the Northwick Park neck pain score ( $10.3 \pm 15.0$  points for PSWD;  $10.2 \pm 14.1$  points for manual therapy) than just exercise and advice alone in 6 months ( $11.5 \pm 15.7$  points); lower scores in the Northwick Park neck pain score indicated lower pain. But, no significant differences existed between the PSWD and manual

therapy groups. However, Dziedric et al.'s study is incomparable to this study due differences in experimental design, subject size, procedure, and focus of study. Instead of a randomized pretest-posttest experimental design like this study, Dziedric et al. utilized a multicenter pragmatic randomized control trial throughout 15 physical therapy outpatient facilities. All subjects were diagnosed with nonspecific neck pain, which differs from this study where subjects had no clinical diagnosis other than decreased ROM. The total number of subjects was approximately 350 for Dziedric et al.'s study, which is significantly larger than this study. Thus, Dziedric et al.'s study can arguably be more reliable than this study. In addition, Dziedric et al. focused on the reduction of pain rather than increasing ROM. It is possible to potentially obtain more significant results if this study followed a similar design and subject size like Dziedric et al.'s study, but focused on ROM rather than pain.

For the subjects who received PSWD, all reported to have felt a gentle warmth during treatment (Table 4). This supports Murray and Kitchen (2000), who stated PSWD, set at a high enough dosage, can trigger a thermal sensation. This subjective information contributes to the overall high ratings of patient comfort from the PSWD subjects (7 ranked very relaxing, and 3 ranked slightly relaxing). A potential positive outcome for these results could be decreased pain. If so, then this study would support the research performed by McCray and Patton (1984) on the comparison pain relief between moist hot packs and PSWD. With the use of a pressure algometer to measure pain, the researchers concluded pain reduction from the PSWD was statistically significant compared to the moist hot pack ( $p = 0.058$ ). However, the amount of patient comfort rather than the level of pain was the qualitative variable in this study. It is encouraged for future studies to analyze improvements in pain perception.

For all subjects who ranked the treatment as slightly relaxing, they reported to have no noticeable improvements after the completion of the study. Out of the seven subjects who ranked the treatment very relaxing, five noticed improvements (Table 5). Examples of the improvements noted included increased muscle relaxation and greater hamstring flexibility. Additionally, some of the comments from the subjects were the following: “warmed superficially,” “was comfortable,” and “provided concentrated heating” for the moist hot pack treatment; “comfortable” and “provided total, consistent heating” for the PSWD treatment. The results follow a similar outcome from Robertson et al. (2005). The researchers utilized a questionnaire to find any correlation between activity and calf stretching involvement, opinion on their heating treatment, and the ROM obtained. As a result, a conclusion could not be obtained due to small correlations between participation in activity and ROM ( $r = 0.17$ ) and calf stretching participation and ROM ( $r = -0.13$ ). The results of the seven subjects in this study who noticed improvements, along with the results of previous studies, show a trend of supporting PSWD increasing patient comfort while improving ROM. With that, there may be an improvement in daily activity.

From the 10 subjects who received the IASTM treatments, eight subjects ranked the treatment as either slightly relaxing or very relaxing. The remaining two subjects, however, ranked the treatment as slightly uncomfortable. This is potentially a result of too much pressure applied during the treatment, which is a possible miscommunication between the subject and the clinician. In addition, targeting adhesions formed from physical activity could have impacted the results. Evidence from Silbaugh et al. (2013) who investigated the validity of IASTM on myofascial adhesions through a diagnostic ultrasound analysis, reported adhesions formed from physical activity. Going over those targeted adhesions could have caused more discomfort



compared to someone who presented a hamstring muscle with no adhesions. Furthermore, the angle of the instrument during muscle stripping may have been too great in this study. For other IASTM instruments such as the Graston<sup>®</sup> Technique, the protocol states the instrument should be held at a 30-60° angle, with the higher angle being more aggressive (Hammer, 2008; Howitt, Jung, & Hammonds, 2009). However, the angle of the AcuForce<sup>®</sup> 7.0 instrument during treatment was not regulated. During the treatment, the examiner attempted to avoid discomfort by asking for constant feedback. However, communication errors may have influenced the results of patient comfort.

### **Limitations of the Study**

This study was limited to the effects of PSWD and IASTM on healthy male NDSU students, faculty, and staff with tight hamstrings. All subjects received a standardized treatment protocol, which means the treatments were not personalized to the individual. Clinically, IASTM treatments vary throughout individuals' cases, based on the clinician's ability to find adhesions in the targeted structure. The IASTM treatment was standardized in this study and, therefore, does not mimic how IASTM treatments are performed clinically. The only alterations made were in situations where the treatment was too uncomfortable, which occurred more often in the IASTM group than the PSWD group. If the areas of adhesions were targeted specifically, the examiner could have potentially seen greater increases in ROM, and a more positive perceived patient comfort.

Based on the inclusion criteria, all subjects were considered healthy. All subjects, except for one, reported to be physically active and continued to participate in their regular activity. Thus, the subjects could have presented damage in the muscles and tendons from past activity (Lorenz et al., 1997). The possible damage could have been a result from minor injuries that the

subjects have previously encountered, and resulted in a possible formation of adhesions or scarring. Consequently, the subjects could have been unaware of their injuries since they were minor. In some of the IASTM subjects, crepitus was felt during treatment, which further supports likely damage in the muscles and tendons. Therefore, the results of this study showed potential for either PSWD or IASTM to treat unhealthy, sub-acute to chronic hamstring injuries. This would be possible due to reduction of adhesions and muscle spasm and an increase in tissue temperature. Recommendations for future research include having physical activity as a greater consideration for inclusion, or focusing on a subject population presenting with unhealthy tissue.

Furthermore, the settings for PSWD treatment was set to trigger a 4° tissue temperature increase, as influenced by academic texts (Knight and Draper, 2013; Starkey, 2004). Instrument Assisted Soft Tissue Mobilization (IASTM) can also increase tissue temperature, as a possible result from peripheral blood flow (Portillo-Soto et al., 2014). However, intramuscular temperature was not measured for this study and, therefore, it is not certain whether tissue temperatures reached a 4° increase in the subjects' hamstrings. For future research, the use of intramuscular thermocouples should be considered to verify temperature increases.

Moreover, the measurement positions for inclusion and pre- and post-treatment were different. The inclusion criteria included 40° to 70° of straight leg hip flexion ROM, which is a position that could have been impacted by other structures that weren't accounted for, including: tight gastrocnemius, ankle positioning, rotation of the hip, and increased lumbar lordosis. The patient positioning for pre-and post-treatment measurements included knee extension while the hip was at 90° of flexion. The positioning for both inclusion and pre- and post-measurements were influenced by recent literature (Nejo et al., 2014; Bates, et al.2016). The results of the study

could have potentially been different if the measurement positions were identical. Also, results could have been compared to the control leg if the positions were the same.

The clinician who provided the treatments is a certified athletic trainer who is knowledgeable in the physiological effects and application of manual therapy and, more specifically, IASTM treatments. However, this study was the first time the clinician utilized the AcuForce® 7.0 on the hamstring. Therefore, a lack of experience from the clinician could have altered the quality of the treatment provided, and all 10 subjects could have potentially reported positive results. Overall, eight out of the 10 subjects noticed improvements at the conclusion of the study, such as increased flexibility and decreased pain. The study shows a trend of supporting the ability of an IASTM treatment to increase patient comfort while improving ROM.

### **Recommendations for Future Research**

This study was only applied to healthy male NDSU students, faculty, and staff with tight hamstrings. Clinically, these treatments are performed on injured patients who present unhealthy tissue. Therefore, further research is needed that investigates the comparison of PSWD and IASTM on injured tissue of the hamstring. Previous studies conducted on ROM have shown gender and age influences on ROM. More specifically, the research has shown greater increases in ROM in women than men, and younger subjects (roughly ages 2-44) than older subjects (roughly ages 45-69) (Hoge et al., 2010; Soucie et al., 2011). Therefore, analyzing differences in results between male and female subjects is needed for further research. Additionally, further research on a more specific age group (younger versus older) is recommended to understand the effects of age, ROM, and treatments.

Moreover, the subjects only reported for three treatment sessions, which may not have been a long enough time to notice lasting effects in ROM. Extending the study to multiple weeks

could have resulted in larger increases in ROM and would be more realistic to the clinical setting. In addition, not all of the subjects had equal time durations between each treatment session. Due to scheduling, some subjects had the minimal amount of 24 hours in between each session, while some had 48+ hours; other subjects had inconsistent time gaps in between treatment session throughout the week. There is a potential for different results if the times were identical throughout all subjects.

To date, no known research exists on the AcuForce<sup>®</sup> 7.0 and its effects on ROM. Due to the limited amount of studies, further research on the instrument is needed. Moreover, studies that compare the AcuForce<sup>®</sup> 7.0 to other types of IASTM instruments could potentially be beneficial. Aside from the AcuForce<sup>®</sup> 7.0, the PSWD model used in the study, Intellect<sup>®</sup> SWD100, hasn't been utilized in research. Therefore, research is needed on the comparison between then Intellect<sup>®</sup> SWD100 and other PSWD modality models.

### **Conclusion**

Pulsed shortwave diathermy (PSWD) and instrument assisted soft tissue mobilization (IASTM) have both been supported by research and literature to be effective options to obtain increases in range of motion (ROM). Clinicians utilize PSWD for its ability to increase tissue temperature at a deeper depth than superficial heat, while targeting a larger surface area than ultrasound. Similarly, clinicians use IASTM to detect and treat adhesions in a way that is safe for the patient and limits the amount of overuse injuries for the clinician. Overall, both treatment options have been supported by this study to have a significant impact on ROM and perceived patient comfort. Clinically, PSWD having a greater impact than IASTM could mean a more impactful recovery from an injury and greater success with obtaining ROM. However, the lack of statistical significance between the two types of treatments in this study is a positive discovery

for clinicians, especially those who don't have the means to have a PSWD machine in their clinic. This study supports the existence of a large variety of treatment options to use that are safe, provide patient comfort, and will assure a positive influence on ROM, thus decreasing injury rates.

## REFERENCES

- Arazi, H., Asadi, A., & Hoseini, K. (2012). Comparison of Two Different Warm-Ups (Static-Stretching and Massage): Effects on Flexibility and Explosive Power. / Usporedba Dvaju Različitih "Zagrijavanja" (Statički-Stretching I Masaža): Učinci Na Gibljivost I Eksplozivnu Snagu. *Acta Kinesiologica*, 6(1), 55-59.
- Baker, R. T., Nasypany, A., Seegmiller, J. G., & Baker, J. G. (2013a). Instrument-Assisted Soft Tissue Mobilization Treatment for Tissue Extensibility Dysfunction. *International Journal of Athletic Therapy & Training*, 18(5), 16-21.
- Baker, R. T., Nasypany, A., Seegmiller, J. G., & Baker, J. G. (2013b). Instrument-Assisted Soft Tissue Mobilization Treatment for Tissue Extensibility Dysfunction. *International Journal of Athletic Therapy and Training*, 18(5), 16-21.  
doi:http://dx.doi.org/10.1123/ijatt.18.5.16
- Bates, H., Gange, K., German Knodel, N., Blodgett Salafia, E. (2016). The Effects of Thermostim Instrument Assisted Soft Tissue Mobilization and Superficial Heat on Range of Motion of the Hamstrings and Perceived Patient Comfort (unpublished master's thesis). North Dakota State University, Fargo, ND.
- Bell, J. (2008). Massage therapy helps to increase range of motion, decrease pain and assist in healing a client with low back pain and sciatica symptoms. *Journal of Bodywork & Movement Therapies*, 12(3), 281-289. doi:10.1016/j.jbmt.2008.01.006
- Bialosky, J. E., Bishop, M. D., George, S. Z., & Robinson, M. E. (2011). Placebo response to manual therapy: something out of nothing? *The Journal of manual & manipulative therapy*, 19(1), 11. doi:10.1179/2042618610Y.0000000001
- Bradbury-Squires, D. J., Nofthall, J. C., Sullivan, K. M., Behm, D. G., Power, K. E., & Button, D. C. (2015). Roller-Massager Application to the Quadriceps and Knee-Joint Range of Motion and Neuromuscular Efficiency During a Lunge. *Journal of Athletic Training (Allen Press)*, 50(2), 133-140.
- Burke, J., Buchberger, D., Carey-Loghmani, M., Dougherty, P., & Dishman, J. (2007). A pilot study comparing two manual therapy interventions for carpal tunnel syndrome. *Journal of Manipulative and Physiological Therapeutics*, 30(1), 50-61.  
doi:10.1016/j.jmpt.2006.11.014
- Calixtre, L. B., Moreira, R. F. C., Franchini, G. H., & Albuquerque-Sendín, F. O., A. B. (2015). Manual therapy for the management of pain and limited range of motion in subjects with signs and symptoms of temporomandibular disorder: a systematic review of randomised controlled trials. *Journal of Oral Rehabilitation*, 42(11), 847. doi:10.1111/joor.12321

- Chalmers, G. (2004). Re-examination of the possible role of Golgi tendon organ and muscle spindle reflexes in proprioceptive neuromuscular facilitation muscle stretching. *Sports Biomechanics*, 3(1), 159-183.
- Clar, C., Tsertsvadze, A., Court, R., Hundt, G. L., Clarke, A., & Sutcliffe, P. (2014). Clinical effectiveness of manual therapy for the management of musculoskeletal and non-musculoskeletal conditions: systematic review and update of UK evidence report. *Chiropractic & manual therapies*, 22(1), 12. doi:10.1186/2045-709X-22-12
- Cornish, C. (2011). Does Compression Massage Increase Hamstring Flexibility of Soccer Players. *Performance Conditioning Soccer*, 16(3), 4-7.
- Cope, L.M., Ivens, J.L., Colston, M.A., Wilkerson, G.B., Louis, J.G. (2014). *Effect of Sub-Occipital Instrument-Assisted Soft Tissue Mobilization on Visuomotor Reaction Time*. Poster presented through University of Tennessee- Chattanooga.
- Cosgray, N. A., Lawrance, S. E., Mestrich, J. D., Martin, S. E., & Whalen, R. L. (2004). Effect of Heat Modalities on Hamstring Length: A Comparison of Pneumatherm, Moist Heat Pack, and a Control. *Journal of Orthopaedic & Sports Physical Therapy*, 34(7), 377-387. doi:10.2519/jospt.2004.34.7.377
- Dahiru, T. (2008). P-value, a true test of statistical significance? A cautionary note. *Annals of Ibadan Postgraduate Medicine*, volume 6 (1). Retrieved from <http://www.scholar.google.com>.
- Delpizzo, V., & Joyner, K. H. (1987). On the Safe Use of Microwave and Shortwave Diathermy Units. *Australian Journal of Physiotherapy*, 33(3), 152-162. doi:10.1016/S0004-9514(14)60592-4
- Deyle, G., Fritz, J., Gill, N., Jones, C., Rot, J., Sizer, P., Courtney, C. (2011). Educational Standard in Orthopaedic Manual Physical Therapy. *American Academy of Orthopaedic Manual Physical Therapists*. Retrieved from <https://aaompt.org>.
- Draper, D. O., Castel, J. C., & Castel, D. (1995). Rate of Temperature Increase in Human Muscle During 1 MHz and 3 MHz Continuous Ultrasound. *Journal of Orthopaedic & Sports Physical Therapy*, 22(4), 142-150. doi:10.2519/jospt.1995.22.4.142
- Draper, D. O., Castro, J. L., Feland, B., Schulthies, S., & Eggett, D. (2004). Shortwave diathermy and prolonged stretching increase hamstring flexibility more than prolonged stretching alone. *Journal of Orthopedic and Sports Physical Therapy*, 34(1), 13-20. doi:10.2519/jospt.2004.34.1.13
- Draper, D. O., Hawkes, A. R., Johnson, A. W., Diede, M. T., & Rigby, J. H. (2013). Muscle heating with Megapulse II shortwave diathermy and ReBound diathermy. *Journal of athletic training*, 48(4), 477. doi:10.4085/1062-6050-48.3.01

- Draper, D. O., Knight, K., Fujiwara, T., & Castel, C. (1999). Temperature Change in Human Muscle During and After Pulsed Short-Wave Diathermy. *Journal of Orthopaedic & Sports Physical Therapy*, 29(1), 13-22. doi:10.2519/jospt.1999.29.1.13
- Draper, D. O., Miner, L., Knight, K. L., & Ricard, M. D. (2002). The Carry-Over Effects of Diathermy and Stretching in Developing Hamstring Flexibility. *Journal of Athletic Training*, 37(1), 37-42.
- Draper, D. O. (2014). Pulsed Shortwave Diathermy and Joint Mobilizations for Achieving Normal Elbow Range of Motion After Injury or Surgery With Implanted Metal: A Case Series. *Journal of Athletic Training*, 49(3). doi: 10.4085/1062-6050-49.3.45
- Dziedzic, K., Hill, J., Lewis, M., Sim, J., & Daniels, J. H., Elaine M. (2005). Effectiveness of manual therapy or pulsed shortwave diathermy in addition to advice and exercise for neck disorders: A pragmatic randomized controlled trial in physical therapy clinics. *Arthritis Care & Research*, 53(2), 214-222. doi:10.1002/art.21087
- Ekstrand J., Gillquist, J. (1983). The avoidability of soccer injuries. *Internation Journal of Sports Medicine*, 4, 124-128.
- Enoka, R., Hutton, R., & Eldred, E. (1980). Changes in excitability of tendon tap and Hoffmann reflexes following voluntary contractions. *Electroencephalography and Clinical Neurophysiology*, 48(6), 664-672.
- Farrell, J. P., & Jensen, G. M. (1992). Manual therapy: a critical assessment of role in the profession of physical therapy. *Physical therapy*, 72(12), 843.
- Forman, J., Geertsen, L., & Rogers, M. (2014). Effect of deep stripping massage alone with eccentric resistance on hamstring length and strength. *Journal of Bodywork & Movement Therapies*, volume 18, 139-144.
- Funk, D., Swank, A. M., Adams, K. J., & Treolo, D. (2001). Efficacy of moist heat pack application over static stretching on hamstring flexibility. / Efficacite de l'application d'une compresse de chaleur moite et d'un etirement statique sur la flexibilite des muscles de la cuisse. *Journal of Strength & Conditioning Research (Allen Press Publishing Services Inc.)*, 15(1), 123-126.
- Garrett, C. L., Draper, D. O., & Knight, K. L. (2000). Heat distribution in the lower leg from pulsed short- wave diathermy and ultrasound treatments. *Journal of athletic training*, 35(1), 50.
- Gibson, M.L., Colston, M.A., Wilkerson, G.B, Louis, J.G (2012). *Effects of Low Back Manual Therapy on Perceived Status Change and Knee Extensor Torque*. Posted presented through University of Tennessee- Chattanooga.



- Giombini, A., Giovannini, V., Di Cesare, A., Pacetti, P., Ichinoseki-Sekine, N., Shiraishi, M., . . . Maffulli, N. (2007). Hyperthermia induced by microwave diathermy in the management of muscle and tendon injuries. *British medical bulletin*, 83, 379.
- Godges, J. J., Mattson-Bell, M., Thorpe, D., & Shah, D. (2003). The immediate effects of soft tissue mobilization with proprioceptive neuromuscular facilitation on glenohumeral external rotation and overhead reach. *Journal of Orthopedics and Sports Physical Therapy*, 33(12), 713-718. doi:10.2519/jospt.2003.33.12.713
- Hammer, W. (2008). The effect of mechanical load on degenerated soft tissue. *Journal of Bodywork and Movement Therapies*, 12(3), 246-256. doi:10.1016/j.jbmt.2008.03.007
- Hanson, M. (2009). Effects of different heating modalities on hip flexion passive range of motion. In: ProQuest Dissertations Publishing.
- Hawkes, A. R., Draper, D. O., Johnson, A. W., Diede, M. T., & Rigby, J. H. (2013). Heating capacity of rebound shortwave diathermy and moist hot packs at superficial depths. *Journal of athletic training*, 48(4), 471. doi:10.4085/1062-6050-48.3.04
- Henricson, A. S., Fredriksson, K., Persson, I., Pereira, R., Rostedt, Y., & Westlin, N. E. (1984). The Effect of Heat and Stretching on the Range of Hip Motion. *Journal of Orthopaedic & Sports Physical Therapy*, 6(2), 110-115. doi:10.2519/jospt.1984.6.2.110
- Hill, J., Lewis, M., Mills, P., & Kielty, C. (2002). Pulsed Short-Wave Diathermy Effects on Human Fibroblast Proliferation. *Archives of Physical Medicine and Rehabilitation*, 83(6), 832-836. doi:http://dx.doi.org/10.1053/apmr.2002.32823
- Hoge, K. M., Ryan, E. D., Costa, P. B., Herda, T. J., Walter, A. A., Stout, J. R., Cramer, J. T. (2010). Gender differences in musculotendinous stiffness and range of motion after an acute bout of stretching. *Journal of Strength and Conditioning Research*, 24(10), 2618-2626.
- Holm, I., Bolstad, B., Lütken, T., Ervik, A., Røkkum, M., & Steen, H. (2000). Reliability of goniometric measurements and visual estimates of hip ROM in patients with osteoarthritis. *Physiotherapy research international : the journal for researchers and clinicians in physical therapy*, 5(4), 241. doi:10.1002/pri.204
- Houghton, P. E., Nussbaum, E. L., & Hoens, A. M. (2010). Electrophysical Agents: Contraindications and Precautions: An Evidence-Based Approach to Clinical Decision Making in Physical Therapy. *Physiotherapy Canada*, 62(5), 63-73.
- Huang, Y. S., Di Santo, P. M., Wadden, F. K., Cappa, G. D., Alkanani, G. T., & Behm, G. D. (2010). Short- Duration Massage at the Hamstrings Musculotendinous Junction Induces Greater Range of Motion. *Journal of Strength and Conditioning Research*, 24(7), 1917-1924. doi:10.1519/JSC.0b013e3181e06e0c

- Jan, M.-H., Chai, H.-M., Wang, C.-L., Lin, Y.-F., & Tsai, L.-Y. (2006). Effects of repetitive shortwave diathermy for reducing synovitis in patients with knee osteoarthritis: an ultrasonographic study. *Physical therapy*, 86(2), 236.
- Johns, L. D. (2002). Nonthermal effects of therapeutic ultrasound: the frequency resonance hypothesis. *Journal of athletic training*, 37(3), 293.
- Jones, M. A. (1992). Clinical reasoning in manual therapy. *Physical therapy*, 72(12), 875.
- Kivlan, B. R., Carcia, C. R., Clemente, F. R., Phelps, A. L., & Martin, R. L. (2015). The effect of Astym® Therapy on muscle strength: a blinded, randomized, clinically controlled trial. *BMC musculoskeletal disorders*, 16, 325. doi:10.1186/s12891-015-0778-9
- Krivickas, L. S., Feinberg, J. H., (1996). Lower extremity injuries in college athletes: Relation between ligamentous laxity and lower extremity muscle tightness. *Archives of Physical Medicine and Rehabilitation*, 77, 1139-1143.
- Laudner, K., Compton, B. D., McLoda, T. A., & Walters, C. M. (2014). Acute effects of instrument assisted soft tissue mobilization for improving posterior shoulder range of motion in collegiate baseball players. *International journal of sports physical therapy*, 9(1), 1.
- Laufer, Y., & Dar, G. (2012). Effectiveness of thermal and athermal short- wave diathermy for the management of knee osteoarthritis: a systematic review and meta- analysis. *Osteoarthritis and Cartilage*, 20(9), 957-966. doi:10.1016/j.joca.2012.05.005
- Lee, J., Lee, D., & Oh, J. (2016). The effect of Graston technique on the pain and range of motion in patients with chronic low back pain. *The Journal of Physical Therapy Science*, 28, 1852-1855.
- Leininger, B., Evans, R., Haas, M., Bronfort, G., & Triano, J. (2010). Effectiveness of manual therapies: the UK evidence report. *Chiropractic and Manual Therapies*, 18(1), 3. doi:10.1186/1746-1340-18-3
- Louis, J. G. (personal communication, March 25, 2017) discusses treatment time of AcuForce® 7.0.
- Lorenz, E. P. M., Zuhike, H. V., Lange, R., Savvas, V. (1997). Pathophysiology and Classification of Adhesions. *Peritoneal Adhesions*, 29-34. doi: 10.1007/978-3-642-60433-1\_4.
- Markovic, G. (2015). Acute effects of instrument assisted soft tissue mobilization vs. foam rolling on knee and hip range of motion in soccer players. *Journal of Bodywork & Movement Therapies*, 19(4), 690-696. doi:10.1016/j.jbmt.2015.04.010

- McCormack, J. R. (2012). The management of bilateral high hamstring tendinopathy with ASTYM® treatment and eccentric exercise: a case report. *The Journal of manual & manipulative therapy*, 20(3), 142. doi:10.1179/2042618612Y.0000000003
- McCray, R. E., & Patton, N. J. (1984). Pain Relief at Trigger Points: Comparison of Moist Heat and Shortwave Diathermy. *Journal of Orthopedic and Sports Physical Therapy*, 5(4), 175-178. doi:10.2519/jospt.1984.5.4.175
- McKechnie, G. J. B., Young, W. B., & Behm, D. G. (2007). Acute effects of two massage techniques on ankle joint flexibility and power of the plantar flexors. *Journal of Sports Science & Medicine*, 6(4), 498-504.
- Meshram, S., Deo, M., & Raj, D. (2015). A probe into practice of the Short wave diathermy (SWD) application in an urban private physiotherapy clinics: a survey from ethical practice & safety perspective. *International Journal of Therapies and Rehabilitation Research*, 5(1), 8-14. doi:10.5455/ijtrr.000000111
- Mohr, A. R., Long, B. C., & Goad, C. L. (2014). Effect of Foam Rolling and Static Stretching on Passive Hip-Flexion Range of Motion. *Journal of Sport Rehabilitation*, 23(4), 296-299. doi:10.1123/jsr.2013-0025
- Moraska, A. (2005). Sports Massage: A Comprehensive Review. *The Journal of Sports Medicine and Physical Fitness*, 45(3), 370-380.
- Mosler, A. B., Blanch, P. D., & Hiskins, B. C. (2006). The effect of manual therapy on hip joint range of motion, pain and eggbeater kick performance in water polo players. *Physical Therapy in Sport*, 7(3), 128-136. doi:10.1016/j.ptsp.2006.04.001
- Murray, C. C., & Kitchen, S. (2000). Effect of pulse repetition rate on the perception of thermal sensation with pulsed shortwave diathermy. *Physiotherapy research international : the journal for researchers and clinicians in physical therapy*, 5(2), 73. doi:10.1002/pri.187
- Nakano, J., Yamabayashi, C., Scott, A., & Reid, W. D. (2012). The effect of heat applied with stretch to increase range of motion: A systematic review. *Physical Therapy in Sport*, 13(3), 180-188. doi:10.1016/j.ptsp.2011.11.003
- Nejo, Y., Gange, K., German Knodel, N., Blodgett Salafia, E. (2014). The Graston Technique® increases hamstring flexibility (unpublished master's thesis). North Dakota State University, Fargo, ND.
- Peres, S. E., Draper, D. O., Knight, K. L., & Ricard, M. D. (2002). Pulsed Shortwave Diathermy and Prolonged Long-Duration Stretching Increase Dorsiflexion Range of Motion More Than Identical Stretching Without Diathermy. *Journal of Athletic Training*, 37(1), 43-50.

- Portillo-Soto, A., Eberman, L. E., Demchak, T. J., & Peebles, C. (2014). Comparison of blood flow changes with soft tissue mobilization and massage therapy. *Journal of alternative and complementary medicine (New York, N.Y.)*, 20(12), 932. doi:10.1089/acm.2014.0160
- Robertson, M. (2008). *Self-Myofascial Release Purpose, Methods, and Techniques*. Robertson Training Systems. Indianapolis, IN.
- Robertson, V. J., Ward, A. R., & Jung, P. (2005). The effect of heat on tissue extensibility: A comparison of deep and superficial heating. *Archives of Physical Medicine and Rehabilitation*, 86(4), 819-825. doi:10.1016/j.apmr.2004.07.353
- Rosario, J. L., & Foletto, Á. (2015). Comparative study of stretching modalities in healthy women: Heating and application time. *Journal of Bodywork & Movement Therapies*, 19(1), 3-7. doi:10.1016/j.jbmt.2013.12.003
- Sefton, J. M., Yarar, C., Carpenter, D. M., & Berry, J. W. (2011). Physiological and clinical changes after therapeutic massage of the neck and shoulders. *Manual Therapy*, 16(5), 487-494. doi:10.1016/j.math.2011.04.002
- Seiger, C., Draper, D. O. (2006). Use of Pulsed Shortwave Diathermy and Joint Mobilization to Increase Ankle Range of Motion in the Presence of Surgical Implanted Metal: A Case Series, *Journal of Orthopaedic & Sports Physical Therapy*, 30(9).
- Shah, S. G. S., & Farrow, A. (2007). Investigation of practices and procedures in the use of therapeutic diathermy: a study from the physiotherapists' health and safety perspective. *Physiotherapy Research International*, 12(4), 228-241. doi:10.1002/pri.382
- Shields, N., Gormley, J., & O'Hare, N. (2002). Short-wave diathermy: current clinical and safety practices. *Physiotherapy Research International*, 7(4), 191-202.
- Shields, N., O'Hare, N., & Gormley, J. (2004). Contra-indications to shortwave diathermy: survey of Irish physiotherapists. *Physiotherapy Research International*, 42-53.
- Silbaugh, K., Demchak, T., Eberman, L., & Wasik, M. (2013) Validity of Instrument Assisted Soft Tissue Mobilization for Detecting Myofascial Adhesions through Secondary Diagnostic Ultrasound Analysis (published Master's thesis). Indiana State University, Terre Haute, IN.
- Soucie, J. M., Wang, C., Forsyth, A., Funk, S., Denny, M., Roach, K. E., Boone, D. (2011). Range of motion measurements: reference values and a database for comparison studies. *Haemophilia*, 17, 500-507. doi: 10.1111/j.1365-2516.2010.02399.x
- Speed, C. A. (2001). Therapeutic ultrasound in soft tissue lesions. *Rheumatology*, 40(12), 1331-1336. doi:10.1093/rheumatology/40.12.1331

- Taniguchi, K., Shinohara, M., Nozaki, S., & Katayose, M. (2015). Acute decrease in the stiffness of resting muscle belly due to static stretching. *Scandinavian Journal Of Medicine & Science In Sports*, 25(1), 32-40. doi:10.1111/sms.12146
- Tepperman, P. S., & Devlin, M. (1986). The therapeutic use of local heat and cold. *Canadian family physician Médecin de famille canadien*, 32, 1110.
- Teslim, O. A., Adebowale, A. C., Ojoawo, A. O., Sunday, O. A., & Bosede, A. (2013). Comparative effects of pulsed and continuous short wave diathermy on pain and selected physiological parameters among subjects with chronic knee osteoarthritis. *Technology and health care : official journal of the European Society for Engineering and Medicine*, 21(5), 433. doi:10.3233/THC-130744
- Threlkeld, A. J. (1992). The Effects of Manual Therapy on Connective Tissue. *Physical Therapy*, 72(12), 893-902.
- van Den Dolder, P. A., Ferreira, P. H., & Refshauge, K. M. (2015). Effectiveness of Soft Tissue Massage for Nonspecific Shoulder Pain: Randomized Controlled Trial. *Physical therapy*, 95(11), 1467. doi:10.2522/ptj.20140350
- van Den Dolder, P. A., & Roberts, D. L. (2003). A trial into the effectiveness of soft tissue massage in the treatment of shoulder pain. *Australian Journal of Physiotherapy*, 49(3), 183-188. doi:10.1016/S0004-9514(14)60238-5
- Voogt, L., de Vries, J., Meeus, M., Struyf, F., Meuffels, D., & Nijs, J. (2015). Analgesic effects of manual therapy in patients with musculoskeletal pain: A systematic review. *Manual Therapy*, 20(2), 250-256. doi:10.1016/j.math.2014.09.001
- Zabel, J. (2015). Factors Influencing the Use of Shortwave Diathermy Among Certified Athletic Trainers. In T. Neuharth (Ed.): ProQuest Dissertations Publishing.
- Zafar, H., Oluseye, K., Alghadir, A., & Iqbal, Z. A. (2015). Perception about the importance and use of therapeutic massage as a treatment modality among physical therapists working in Saudi Arabia. *Journal of physical therapy science*, 27(6), 1827. doi:10.1589/jpts.27.1827

## APPENDIX A. CHATTANOOGA SHORTWAVE DIATHERMY



Note: Model used for diathermy. <https://www.djoglobal.com/products/chattanooga/intelect-swd100>

## APPENDIX B. ACUFORCE® 7.0



Note: Instrument utilized for instrument-assisted soft tissue mobilization.  
<http://www.acuforce.com/products.html>

## APPENDIX C. HANDMADE APPARATUS



Note: Apparatus used to maintain 90° hip flexion while measuring knee extension.



## APPENDIX D. ACTIVITY QUESTIONNAIRE

Name: \_\_\_\_\_

Subject Number: \_\_\_\_\_

### Activity Questionnaire

(please only check one box for each question)

1. What is your age?

18-25    26-35    36-42    43-50

2. Are you physically active?

Yes    No

3. How many times a week, on average, are you active?

none    1-2 days/wk    3-4 days/wk    5-6 days/wk    7 days/wk

4. What does your physical activity typically consist of?

cardio    weight training    college athletics    recreational activity

Other: \_\_\_\_\_    Combination: \_\_\_\_\_

**APPENDIX E. PATIENT FEEDBACK QUESTIONNAIRE**

Name: \_\_\_\_\_

Subject Number: \_\_\_\_\_

**Patient Feedback**

1. What treatment did you receive?

Pulsed Shortwave Diathermy  
(PSWD)

Instrument Assisted Soft Tissue Mobilization  
(IASTM)

2. Did you feel a warmth during the Shortwave Diathermy treatment (if received)?

Yes

No

N/A

3. How would you describe the Pulsed Shortwave Diathermy Treatment? (do not answer if you received the IASTM treatment)

Very Uncomfortable

Slightly Uncomfortable

Neutral

Slightly Relaxing

Very Relaxing

N/A

4. How would you describe the Instrument Assisted Soft Tissue Mobilization Treatment? (do not answer if you received the PSWD treatment)

Very Uncomfortable

Slightly Uncomfortable

Neutral

Slightly Relaxing

Very Relaxing

N/A

5. Would you get that treatment again?  Yes  No

6. Explain why you would/would not get the treatment again. \_\_\_\_\_

\_\_\_\_\_

(next page)

7. Did you notice any improvements in the past week of treatment?

Yes

No

8. If yes, explain what improvements you have noticed. \_\_\_\_\_

\_\_\_\_\_