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Comparison Of Blood Flow Changes With Soft Tissue Mobilization And Massage Therapy

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ABSTRACT

Context: Instrument Assisted Soft Tissue Mobilization (IASTM) and massage therapy are manual techniques that claim to be able to increase blood flow to treated areas. There are no studies on human subjects that have directly investigated the effects of IASTM on blood flow. **Objective:** To compare the effects of Graston Technique (GT) and Massage therapy on calf blood flow, using skin temperature measures (a valid, indirect measureof blood flow), on the lower leg. **Design:** Single-blinded prospective, longitudinal, controlled, repeated-measures design. **Setting:** Research Laboratory **Participants:** 28 volunteers participated in the study (Age=23±3; Males=14/28 (50%); Females=14/28 (50%); Girth=39.5±4.3l; Skinfold=27.9±5.6) **Interventions:** Each participant received 10-minute treatment (Massage and IASTM) in two separate sessions with the non-treatment leg used as a control. **Main Outcome Measures:** We measured baseline skin temperature on the calf prior to treatment, and again every 5min after treatment for a total of 60min. We evaluated differences between conditions (4) and time (13) with a repeated measures ANOVA. Significance was set at $p<0.05$ a-priori. **Results:** We identified significant differences with Greenhouse-Geisser corrections between conditions ($F_{2.4,61.2}=39.252$, $p<0.001$, ES=0.602) and time ($F_{2.1,54.4}=192.8$, $p<0.001$, ES=0.881), but failed to achieve a significant main effect ($F_{2.1,53.5}=2.944$, $p=0.060$, $1-\beta=0.558$). The massage condition (32.05±0.16°C) yielded significantly higher skin temperatures as compared to the massage control (30.53±0.14°C, $p<0.001$), GT (31.11±0.20, $p<0.001$), and GT control (30.32±0.14,$p<0.001$) conditions. Only the control conditions were not significantly different from one another ($p=0.189$). We also identified significant differences in time, whereas the baseline (25.83±0.30°C) acquired prior to treatment was significantly lower than all other temperature measurements ($p<0.001$). Moreover, temperatures at 5min (30.21±0.12°C), 10min (31.00±0.30°C), and 15min (31.65±0.12°C) showed significant increases ($p<0.001$). After 15min, the skin temperatures continued to rise and each time point was statistically different from the baseline and up to the 25min peak temperature (31.76±0.12°C), but these differences were not clinically significant differences (<0.80°C). **Conclusion:** This study demonstrated that massage and GT increase skin temperature. A rise in temperature theoretically indicates an increase in blood flow to the area. Blood flow increases theoretically stimulate the delivery of nutrients and oxygen to tissues in the body, increase tissue mobility, and increase muscle flexibility. Massage had a higher temperature increase when compared to GT, but both techniques increased temperature consistently for up to 25min post treatment. Further research is needed to conclude how deep this temperature and blood flow increase is occurring in the muscle tissue. If a clinician's therapeutic goal is to increase temperature and blood flow, both massage and GT would be good treatment choices with massage yielding significantly higher temperature and blood flow. **Word Count:** 422

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CHAPTER 1

INTRODUCTION

Instrument Assisted Soft Tissue Mobilization (IASTM) and massage therapy are manual techniques that claim to be able to increase blood flow to areas in the body treated by a clinician [1-8]. Many researchers and clinicians have investigated the effects of massage on blood flow, and many of the results found are controversial and inconclusive [1-3, 9, 10]. In regards to IASTM, there are no studies on human subjects that have directly investigated the effects it has on blood flow.

IASTM is a manual therapy technique that has been around since the development of Gua Sha in 220BC, and uses instruments that are designed in a unique way in order to be able to apply a force and to detect soft tissue lesions during treatment [8, 11-13]. Massage is a manual therapy technique in which different strokes and hand motions are performed in order to achieve a therapeutic goal [9, 14-16]. These two common forms of manual therapy techniques are used frequently to break down Myofascial adhesions in the connective tissue in our body. These restrictions usually involve the adhesion of two structures together that do not allow normal fiber mobility and cellular or blood flow and circulation to occur [17-20]. Therefore by breaking down Myofascial adhesions, the claim and belief is made that blood flow is improved in the area [6, 8, 17-20]. However, this clinical effect has yet to be determined.

This research study has two aims: 1) To study the effects of Graston Technique and Massage therapy on calf blood flow post-treatment on the lower leg 2) to compare any differences in calf blood flow measures from the two treatment groups.

Research Questions

- Does Graston Technique increase lower leg blood flow after treatment on the calf?
- Does massage therapy increase lower leg blood flow after treatment on the calf?

Hypothesis

- H_0: Lower leg blood flow will not change after a Graston Technique treatment or a Massage Therapy treatment to the calf.
- H_1: Lower leg blood flow will change after a Graston Technique treatment to the calf.
- H_2: Lower leg blood flow will change after a Massage therapy treatment to the calf.

Operational Definitions

1. Graston Technique (GT): A form of instrument assisted soft tissue mobilization that utilizes 6 different shaped stainless steel instruments to detect and treat myofascial adhesions[7, 21]. One of the main clinical benefits that GT claims to do is the increase of blood flow and circulation to muscle tissue[6, 21], which is the effect being investigated in this study.
2. Treatment time: The length of treatment time for GT and massage will be 10 minutes per participant.
3. Healthy: Participants and volunteers for this study who currently do not have a lower extremity injury or have not had one for the past 6 months, not diagnoses with an allergic condition to the emollient or have any conditions for contraindications for massage or GT.

4. Moderate physical activity: Individuals who engage in aerobic or anaerobic exercise at least 3 times per week for 20-30 minutes at each time.
5. Resting position: Patient lying quietly and in a comfortable supine position on the treatment table.

Assumptions

- Participants will answer the health history questionnaire honestly
- Participants will not have a lower extremity injury since the last 6 months from the day of the study
- Participants will represent a moderate physically active population

Delimitations

- Using Graston Technique treatment as the IASTM
- Massage treatment that will last for 10 minutes per participant on the lower leg
- Not incorporating the entire Graston Technique protocol, which includes warm-up, treatment, stretching, strengthening, and ice.

Limitations

- There are no known limitations to this study at this time.

CHAPTER 2

REVIEW OF LITERATURE

This review of literature discusses fascia, facial adhesions, and myofascial release techniques focused in massage therapy and instrument assisted soft tissue mobilizations (IASTM). It includes a summary of massage and its effects on blood flow, as well as any research on IASTM and blood flow and circulation effects. Four different methods for measuring blood flow will also be explained including: Doppler diagnostic ultrasound, Venous Occlusion Plethysmography, Infrared Spectrometer, and Laser Doppler Flow Amplifier.

Search Strategy

Databases: Medline via EBSCO, Pubmed, Pubmed Central, Sports Discus via EBSCO
Search Words: "Graston Technique", "Graston Technique AND fascia", "Myofascial adhesions", "Graston Technique AND Blood flow", "Instrument Assisted Soft Tissue Mobilization Therapy", "Soft tissue mobilization AND Blood flow", "Massage Therapy", "Massage therapy AND Blood flow", "Doppler Diagnostic Ultrasound", "Plethysmography", "Infrared Spectrometer", "Laser Doppler Flow Amplifier"

Inclusion Criteria

- Articles in the English language

- Health care professions: Athletic Training, Physical Therapy, Chiropractors, Massage therapy, and any others that perform therapeutic interventions for the improvement of blood flow in soft tissue.
- Articles involving measurements of blood flow with Laser Doppler Flow Amplifier, Doppler Diagnostic Ultrasound, Venous Occlusion Plethysmography, or Infrared Spectrometer, after a therapeutic intervention to soft tissue

Fascia

Fascia is a soft tissue component that is part of the connective tissue system in our body [17]. Fascia has also been described as a continuous viscoelastic tissue that is composed of a functional 3-dimensional collagen matrix [18]. This viscoelastic membrane encloses muscles, bones, and organs, and plays an important role in the dynamics of our musculoskeletal system such as the transmission of mechanical forces between muscles [17, 18]. The three fundamental structures of fascia are: the superficial fascia or epimysium; deep fascia or perimysium; and the muscle-related layers or endomysium [17]. Fascia is also said to be multidirectional and everywhere in our body, surrounding our organs, serving in the attachment of muscles to bones, and giving our body structure with flexibility [22].

For the purpose of this study, this viscoelastic soft tissue will be referred to as myofascia, which is a term that defines muscle-tissue (myo-) and its web of connective tissue (fascia-) [19].

Composition/Histology

Deep myofascia is composed of denser, regular connective tissue that has a parallel type of fiber bundle arrangement [23]. When describing fascia at a cellular level, Gray describes the extracellular matrix as the sum total of extracellular substance within the connective tissue [19]. Fascia is composed of specific cells, ground substance, and fiber [18]. As described by Shah and

Bhalara, fascia has an elastocollagenous complex with elastin fibers, and collagen fibers that are entrenched in gelatinous ground substance [20]. This gel like consistency of ground substance allows fiber mobility and cellular circulation to occur [20].

Fascial Adhesions

Fascial adhesions are also known as impediments or restrictions in the fascia/myofascial tissues in our body, they may involve the adhesion of two structures together [24, 25]. These restrictions can be located through palpation or manual muscle testing by moving the muscle through its range of motion [24, 25]. These restrictions have a fibrous texture feel upon palpation and have been described as “ropey” or “leathery”, and they restrict normal functioning of muscle range of motion [24]. When a clinician treats adhesions they feel like they are breaking the tissue [24, 25].

Tensegrity

Tensegrity refers to “tension integrity” as defined by R. Buckminster Fuller [19]. In other words, tensegrity is a term used to describe a structure that is able to maintain its integrity due to a balance of woven tensile forces that are continual through the structure, and therefore does not resemble a stone wall that has instead a continuous compressive force [19]. Fuller further describes that tensegrity structures are composed of continuous tension around localized compression [19].

The body manages a balance between tension and compression in order to create a stable structure [19]. The myofascia in our body essentially works through the concept of tensegrity [19]. This connective tissue is a continuous network that restricts but also adjusts tension around individual bones, cartilage, organs, and muscles [19]. Tensegrity forces are not localized forces, they are instead distributed around the body. More specifically, Myers describes the bones as being the primary compression members of our body, but states that they also have tensile properties. On the contrary, myofascia is the primary tensile member which can also carry compression forces [19]. The compressive members in our body are in charge of keeping a structure from collapsing, while tensional members help the compressive members rearrange themselves [19].

One of the most important concepts and ideas about tensegrity is that myofascial meridians are continual bands that hold tensile forces from bone to bone [19]. The continuous structures through the anatomical meridians explain how an increased tension in a specific section of the myofascia will result in an increased tension in other sections throughout the structure [19].

Plasticity versus Elasticity

Muscle is elastic while fascia is plastic [19]. A stretched muscle will try to recoil back to its original length before giving up and trying to add more cells and sarcomeres to bridge a gap [19]. On the other hand, fascia that is stretched quickly will tear, and if the stretch is a slow one, it will deform plastically [19]. This means that it will change its length and as a result will keep that change [19]. The mechanism of fascial deformation is still not fully understood, however it is known that once fascia is truly deformed, it will not come back to its original length and form [19]. When fascia is permanently stretched or deformed, it will lay down new fibers that will rebind a damaged area, but this is not the same concept as elastic recoil within the same tissue [19]. It is important for practicing therapists to understand the differences between plasticity and elasticity, as it is fundamental to a successful application of sequential fascial manipulation techniques [19].

Myofascial Release Techniques (MFR)

Myofascial release (MFR) involves manual therapy techniques designed for breaking down and releasing bonds and restrictions found in our body's connective tissue known as fascia [20, 22, 24, 26]. The purpose of MFR is to stretch the fascia and break any adhesions in the tissue to cause a relief of acute and/or chronic pain, increase range of motion, decrease any structural imbalances, decrease muscle spasm and muscle guarding, and increase the mobility of soft tissue [20, 22]. Myofascial release involves a number of different manual techniques that are all designed in some way or another, with the purpose of relieving soft tissue from myofascial trigger points [4, 22].

Shah et al. identify three different types of MFR: direct, indirect, and self myofascial release [20]. Direct myofascial technique is described as a method that works directly on the fascia that is restricted [20]. The pressure that is applied is focused on the adhesion or spasm, and the practitioner makes use of the knuckles, elbows, fist, or other tools that will aid in applying that slow but focused pressure on the fascia [4, 20]. Direct MFR is mainly used for breaking down and mobilizing any adhesions in the tissues [20]. Indirect MFR, or slow sweeping pressure as described by Paolini, is a more gentle manipulation of the tissues, in which the practitioner focuses on gentle stretching to allow the fascia to "unwind" [20]. Thirdly, self myofascial release involves an individual using a soft object to produce myofascial release on themselves and at their own, pace, body weight, and power [4, 20].

For this study, specifics on the different techniques of myofascial release found in the literature and available in the market will be discussed in the following sections.

Massage Therapy

The era of modern massage dates back to the year 1863 [15]. Such era is marked by findings and publication of a systematic discourse that classified massage techniques based on the body system affected [15]. Massage has been described as a manual therapy technique in which hand motions are performed on the surface of the body in order to achieve a therapeutic goal [4, 15, 16]. According to Paolini, massage is a therapeutic technique that is employed for the alleviation of pain; increase fluid mobilization and soft tissue mobility; decrease heart rate, blood pressure, and anxiety; as well as many other beneficial outcomes [4].

There is a number of evidence in the literature that discuss all of the different therapeutic effects of massage therapy, these range from the increase in blood flow to tissues; helps in the prevention of blood clotting; reducing swelling; reducing discomfort associated with muscle spasms; improvements on flexibility; increased in skin and muscle temperature; and some beneficial effects in delayed onset muscle soreness (DOMS) [1, 14, 15, 27, 28] There are a number of different techniques for massage therapy (Table 1), and they are all used according to clinician's experience and to the specific outcome desired [27].

One of the most common clinical benefits of massage that has been explored by researchers is the effect of blood flow in the tissues. Massage is thought to increase circulation and blood flow [1-3]. If blood flow is increased, the oxygen delivery to muscle tissues is increased, and therefore believed to help in the healing process of injured tissues, metabolite removal, and a return to homeostatic balance [3]. A number of studies have attempted researching its circulatory effects, but there are many controversial outcomes that have already been explored in previous literature reviews [1-3, 29]. Appendix B. *Summary of Massage and its effects on blood flow* lists a few of the many research articles that discuss their findings on massage and blood flow.

Table 1. Types of Massage

Technique	Definition	Claimed clinical benefits
Effleurage	Effleurage are slow stroking and gliding hand movements that are performed at the beginning and end of a massage treatment [15, 16, 27, 30, 31].	This technique claims to relax the muscles and to relieve any present muscle spasms [15]. If the pressure applied is a firm one, then benefits claimed include an improvement on blood and lymph flow, as well as tissue drainage [15]
Petrissage	This technique involves slow circular motions with compression on the soft tissues[15, 16] . It is done on smaller body regions that area treated mainly using the fingertips [15, 16, 30]. Commonly words used to describe it: lifting, kneading, wringing, pressing, rolling [31]	Increased mobilization of deep muscle tissue, as well as increased local circulation and increased venous return [27]
Friction	Technique is done using the fingertips and application of penetrating pressure in a circular or transverse direction to the tissues, specifically to the site of injury [15, 16, 30].	Most commonly used for breakage of adhesions, reduction of pain, and breakage of muscle spasms [15, 27].
Tapotement	It is a percussive type of massage in which the therapist "cups" his or her hands and delivers gentle but rapid strikes to the patient's skin with the concave shape of the hands. Other common techniques are described as: "hacking", "clapping", "beating", "pounding" [15, 16, 30]	The hollow space traps the air cushioned next to the skin causing vibrations, and this claims to help with triggering cutaneous reflexes and vasodilation [15, 27]
Vibration, shaking	This technique employs rougher types of vibrations that are delivered to the skin and tissues with the clinician's hands trembling firmly against the patient's body part [15, 16, 30].	Claims in helping to reduce swelling and edema [15]

Active Release Technique (ART)

Active Release Technique is a manual therapy technique that involves soft tissue movements based on massage techniques. ART is used to treat muscles, tendons, fascia, and nerves [30, 31]. This manual therapy technique was developed, refined, and patented by P. Michael Leahy, DC, CCSP [32]. It claims to be able to help quickly and permanently resolve issues classified as overused muscles or overuse conditions such as: headaches, back pain, carpal tunnel syndrome, shin splints, shoulder pain, sciatica, plantar fasciitis, knee problems, and tennis elbow [32]. This technique is based on the theory of cumulative trauma disorder (CTD), which is described as a soft tissue injury that results from acute, repetitive, or constant pressure/tension injury [33].

An ART treatment session consists of a combination of examination and treatment, in which the clinician evaluates tissue texture and tightness with his or her hands [32, 34]. The tissues are treated by using precise direct tension with specific patient movements [32]. There are over 500 specific movements that are used in ART, all of which consist of a shortening of the tissue being treated, applying a contact tension and then lengthening the tissue relative to the adjacent tissue [32, 34].

Instrument Assisted Soft Tissue Mobilization (IASTM)

Instrument Assisted Soft Tissue Mobilization (IASTM) is a manual therapy technique that uses instruments that are shaped in a unique way in order to be able to apply a force and to detect soft tissue lesions during treatment (Appendix B) [8]. These instruments allow the clinician to apply different strokes and depths to the treated area [8]. Evidence of the first instrument assisted tool dates back to around 220 B.C. with Gua Sha [11, 13]. Gua Sha is a traditional East Asian healing technique that involved using smooth edged instruments to "scrape" and stroke the body part being treated until ecchymosis and petichiae were intentionally produced [11-13]. IASTM is based on the concept of cross-fiber massage (CFM), which is a manual therapy technique that uses forces applied directly and transverse to the treated connective tissue[8]. When using CFM, there is very little motion and skin contact between the therapist and the patient [8]. There are about 30 different companies out in the market who make and advertise instrument assisted soft tissue mobilization tools. Appendix B [35] from Silbaugh's research study "*Validity of Instrument Assisted Soft Tissue Mobilization for Detecting Myofascial Adhesions through Secondary Diagnostic Ultrasound Analysis*", is a summary of the tools that are out in the market.

Graston Technique

Graston technique is a type of IASTM that claims to effectively break down scar tissue and fascial impediments [21, 36]. This technique consists of six stainless steel instruments that are of different shapes, which specifically detect and treat areas that show soft tissue fibrosis or chronic inflammation [21]. The different shapes of the instruments consist of either a convex/concave angles designed to fit all different contours and parts of the body [21].

These stainless steel instruments claim to work like a tuning fork by resonating the adhesions into the clinician's hands, and also help in treating deeper restrictions because of the metal solid surface [21]. More specifically, Graston technique claims to benefit acute and chronic conditions including: cervical sprain/strain, carpal tunnel syndrome, lateral epicondylitis, rotator cuff tendinosis, achilles tendinosis, lumbar sprain/strain, plantar fasciitis, medial epicondylitis, patellofemoral disorders, fibromyalgia, and trigger finger [21, 36-38].

General benefits and clinical concepts of Graston Technique or soft tissue mobilization as described in the clinician's manual include: release of fascial restrictions and adhesions, separates and breaks down collagen cross-links, splays and stretches connective tissue and muscle fibers, increases skin temperature, facilitates reflex changes in chronic muscle holding patterns, alters spinal reflex activity, increases rate and amount of blood flow to and from area, increases cellular activity including fibroblasts and mast cells in the region, and increases histamine responses secondary to mast cell activity [7, 36, 38].

Loghmani conducted a study to specifically investigate the effects of instrument assisted cross fiber massage (IACFM) on tissue level healing through increased blood flow and angiogenesis of knee medial collateral ligament (MCL) injuries [6]. This study was a controlled animal study in which twelve rodents underwent surgical transection of bilateral knee medial collateral ligament (MCL) injuries [6]. GT was performed 1-week post injury and consisted of 3 total sessions a week for 1 minute per session, and a total of 3 weeks was done [6]. Rodents' contralateral injured MCLs where not massaged or treated and served as controls [6]. Researchers used Laser Doppler perfusion imaging (LDI) at different points in time to obtain results on regional tissue perfusion [6]. Results showed no significant changes between IACFM-treated and the contralateral side during the following times: 5, 10, 15, and 20 minutes post treatment [6]. They did find a significant difference 24 hours after the 4th and last treatment session, and at 1-week post-final treatment session [6]. Loghmani concluded from her study that Graston Technique causes an increase in regional blood flow when treating injured ligaments [6]. Her conclusions state that this change is not caused immediately after treatment possibly because of vasodilation in the tissue, but suggests stimulation in angiogenesis with repeated treatments over time [6].

Blood Flow in Soft-Tissue

There are three main types of complex systems within the circulatory system that control blood flow to different parts of the body [39, 40]. These include: local control of blood flow, nervous control of blood flow, and humoral control [39, 40]. For the purposes of this study, the focus will be on the local control of blood flow with emphasis on soft tissue.

Each tissue in the body has the ability to control its own local blood flow in proportion to its need [39]. Moreover, as the need for blood flow change, this flow follows the change [39]. Specific needs of the tissues for blood flow include: delivery of oxygen to the tissues, delivery of other nutrients, removal of carbon dioxide from the tissues, and removal of hydrogen ions from the tissues [39]. A local vascular bed functions primarily through a microcirculatory system [39]. In this system, blood enters a capillary bed through a small arteriole and leaves through a small venule [39, 40]. Resistance vessels are small arteries and arterioles that are responsible for regulating the blood flow around the body [40]. These vessels provide the greatest resistance to blood flow pumped to tissues by the heart and their walls are mainly composed of smooth muscle fibers [40]. Contraction and relaxation of arteriolar vascular smooth muscle help in regulating peripheral blood flow in the body [40].

There are two different phases for local blood flow control including: acute control, and long-term control [39]. Acute control refers to fast changes that happen within seconds to minutes in order to provide a fast way for keeping homeostasis within the tissues, for example the provision of the necessary amounts of oxygen [39]. On the other hand, long-term control refers to slow changes that happen within days to weeks or months, for example a change on the increase or decrease in the sizes and numbers of blood vessels in bodily tissues [39].

Two additional intrinsic control mechanisms of peripheral blood flow that occur in the body are: autoregulation and the Myogenic Mechanism [40]. Autoregulation refers to the mechanism in our body that helps maintain a constant level of tissue metabolism, including oxygen consumption, whenever the body experiences changes in perfusion pressure (arterial blood pressure) and changes with vascular resistance [40]. Autoregulation works along with the myogenic mechanism in regards to the constancy of blood flow in the body in the presence of altered perfusion pressure [40]. This mechanism explains vascular smooth muscle contraction in response to an increase in transmural pressure stretch, which is followed by the smooth muscle relaxing because of a decrease in transmural pressure [40]. More specifically, the endothelium of the vascular smooth muscle is able to elicit a vasoactive response when it is stimulated [40]. The vasoactive response is likely to be caused by the nitrogen oxide that is being released from the endothelium because of the shear stress that is resulting from the increase in velocity of flow [40]. Shear stress can also strip the endothelium from the arteriole which would decrease its ability to dilate when blood flow increases to the area [40].

Blood circulation in the body can also be controlled through humoral control, which involves the effects of vasodilators and vasoconstriction substances [41]. One of this main vasodilators is histamine, which is largely derived from mast cells from injured tissues and basophils in the blood [41]. This humoral substance has a powerful vasodilator effect on arterioles and the ability to increase capillary permeability [41]. The activity and leakage of histamine is controlled by the sympathetic nervous system, and when this sympathetic control is withdrawn, then the mast cells release histamine [41]. In relation to massage, Goats states that forceful massage in healthy individual causes an increase in local blood flow and cardiovascular stroke volume [14]. The local increased of blood flow is believed to occur because of an increase in histamine release by the tissues being treated, whereas the cardiac stroke volume increase is due to increased venous return [14].

There are a number of methods and instrumentations to measure peripheral blood flow that have been employed by clinicians and researchers across many fields. Table 4. Methods for measuring blood flow, is a detailed summary on the most common methods found in the literature that have for measuring muscle and skin blood flow in human subjects.

Table 2. Methods for Measuring Blood Flow

Method	What it measures	Advantages	Disadvantages
Pulsed Doppler velocimetry/ Doppler ultrasound	Blood flow by measuring red blood cells velocity and provides beat-by-beat MBV and blood vessel diameter measures [29, 42].	- Has been highly correlated with electromagnetic flowmeter measures and VOP with controlled conditions, and has shown a strong linear relationship (r=0.99, and r2=0.87 [43]) between the measured MBV and actual blood velocity through plastic tubes [29, 42]. - Gives data and feedback during an actual massage treatment, or beat-to-beat measures of blood flow [29, 30, 42, 43].	- Lack of discrimination for intramuscular distribution of blood flow [42]. - Measures can be variable and absolute values of flow are dependent on angle of insonation [43].
Venous Occlusion Plethysmogr aphy	- Used to determine total muscle perfusion [29] - Measures resting blood flow, and changes in blood flow related to physiological and pharmacological interventions [44]	- VOP has been found to have a high correlation (≈0.8) between plethysmography and brachial artery electromagnetic flow probes during forearm exercise [43]. - High correlation reported (r^2= 0.87 – 0.98) between VOP and Doppler ultrasound with the brachial artery [43] - Non-invasive, inexpensive, and simple principle and practice [43, 44] - 0.86 Pearson correlation found	- Overestimates muscle blood flow due to local hyperemia following the trauma of injection [29, 42]. – Inflation cuff reduces arterial diameter and blood velocity, as a result creating an underestimation of blood flow [27, 29, 42]. - Strain gauge is very sensitive to movement artifact, causing in many studies short pauses between treatments in order to collect data on blood flow; no data can be collected during massage treatment [27, 29, 43].

		between VOP and Doppler ultrasound when measuring lower leg blood flow [45]. - High correlation reported (r^2=0.85) between the use of NMRI and VOP when measuring blood flow during post-ischemic reactive hyperemia [46]	- This technique should not be used when measuring very high arterial inflow associated with exercise because it leads to an underestimation of blood flow [44, 47]
Near Infrared Spectroscopy (NIRS)	Assesses intramuscular blood flow through measurements of oxygen saturation in the tissues [48]	- Assesses intramuscular blood flow in a non-invasive way [2] - It allows researcher to perform repeated measures without the patient feeling discomforts from other invasive procedures [2]. - Portable equipment and inexpensive ($4,000 - $25,000) [48]	- When it takes measurements for skeletal muscle the light sources do not cycle fast enough, so time resolution is not as fast as it could be [48] - Current 4x12cm imaging arrays can be too large for taking measures on single muscles [48]
Dynamic Infrared Thermography (DIRT)	- Indirectly assesses changes in peripheral blood perfusion through quantification of skin temperature that can be correlated to qualitative measures of skin blood flow [1] - DIRT produces a thermal map by measuring the radiant heat that is emitted from the skin's surface [1]. This method uses software	- DIRT provides a real-time, noncontact assessment of temperature changes on skin [1]	- The measures are indirect changes in peripheral blood perfusion through skin temperature values, it is not a measure of muscle tissue [1].

	that produces high resolution images that are then analyzed for any body region that is chosen [1]. The software also provides regional measures of mean, standard deviation, high and low temperatures, and point specific measurements [1].		
Laser Doppler Flowmetry	- Measures blood flow at a continuous real-time qualitative measurement of cutaneous microvascular blood flow [3, 49]. - This method detects the mean velocity of all moved cells and particles that are within the tissue being measured [49]. The laser portion of this method works by illuminating the tissues with a coherent laser light of 830 nm and 30 mW from a laser diode through a fiber optic light guide [49].	- Maximum depth of penetration of the signal is from 0.4 mm to 1 mm [3], meaning that the results of blood flow measures with this instrument will only be based on a cutaneous or skin level and not at a muscular depth [3].	- Intrasubject variability has been reported to be 5%, which suggests that laser Doppler to be a reliable method when performing research with enough standardized test conditions [49]

Venous Occlusion Plethysmography

Venous occlusion plethysmography (VOP) has been a widely used method to measure limb blood flow [43, 44, 50, 51]. General principles of plethysmography date back to the 1800s and the application of these principles began in the early 1900s [43, 44, 51]. VOP has played an important role in the study of limb blood flow, more specifically involving vasodilator responses related to exercise, hyperemia, ischemia, body heating, and mental stress [43].

The main idea on how VOP works is through an inflation cuff that is placed around the body limb, either arm or leg, and it is inflated to a pressure lower than the subjects diastolic pressure [43, 51]. The reasoning behind inflation pressure lower than diastolic pressure is so that venous outflow can be obstructed while arterial flow in a limb can continue [43, 51]. When the limb is placed under these conditions, it is believed to increase in volume [43, 51]. Moreover, it is believed that the rate of increase in limb volume is proportional to the rate of arterial inflow when the vein of the limb being studied is placed above heart level position [43, 51].

According to Joyner et al., it is difficult to assess a definite “absolute” validity of VOP when comparing it to other methods of limb blood flow measure [43, 51]. Even though there is still no “gold standard” for measuring limb blood flow in humans, VOP has been found to have a high correlation (≈0.8) when compared to brachial artery electromagnetic flow probes during forearm exercise in a study by Longhurst and colleagues [43]. However, they did note that this correlation was not high when there were high flows and VOP would overestimate the values of increased blood flow found [43].

Moreover, there has been another high correlation reported (r^2= 0.87 – 0.98) between VOP and Doppler ultrasound with the brachial artery [43, 44, 47]. Conclusions made by Joyner et al. about VOP in this care is that it still remains as the best technique to use when wanting to achieve accurate and repeatable measures of limb blood flow over multiple cardiac cycles when in the forearm or gastrocnemius area [43]. Kooijman et al. conducted a study that tested leg blood flow with VOP and compared reliability and applicability with superficial femoral artery as measured by Doppler ultrasound (DU) [45]. In this study, they found a high agreement between VOP and DU as indicated by 0.86 Pearson correlation in their statistical results and analysis [45]. In relation to reproducibility of VOP and head-up tilt (HUT), authors of the same study found that it was a fair reproducibility when measuring blood flow in a supine position and 30 degrees of HUT (Coefficient of Variation: 11% - 15%), indicating that VOP is an applicable tool to measure leg blood flow during HUT [45].

Summary

IASTM and different techniques of massage therapy claim to be able to increase blood flow to the body areas treated by a clinician. There are no clinical reports or empirical evidence on human subjects to date on the use of IASTM and its effects on blood flow. It is necessary to determine the effects that IASTM has on muscle and connective tissue in regards to local blood flow and circulation.

CHAPTER 3

METHODS

Research Design

The study will consist of a single-blinded prospective, longitudinal, controlled, repeated-measures design. The independent variables include treatment and time. Treatment has three levels Massage (M), Graston Technique (GT), and Control (C). Time has six levels Pre-treatment; immediately, 5-minutes, 20-minutes, 40-minutes, and 60-minutes post-treatment. The dependent variable is lower leg blood flow and will be measured by using Venous Occlusion Plethysmography.

Participants

Healthy participants between the ages of 18-35 will be recruited for this study. Participants will be excluded if: they have any lower leg injuries for the past 6 months, possess any absolute or relative contraindications for IASTM and massage therapy.

Absolute contraindications for IASTM and massage include: local infections, open wounds, unhealed sutures, ulcers, unhealed fractures, thrombophlebitis, uncontrolled hypertension, kidney dysfunction, hematoma, myositis ossificans, infections such as tuberculosis, osteomyelitis, cellulitis, patient intolerance/non-compliance/hypersensitivity to the treatment or the emollient cream by Graston Technique [7, 52].

Relative contraindications for IASTM and massage include: medications (steroids, anti-coagulants, hormone replacement therapy), cancer, varicose veins, burn scars, acute inflammatory conditions (synovitis, bursitis), inflammatory reactions secondary to infections, acute inflammatory sites or stage of autoimmune diseases (Rheumatoid Arthritis, Lupus, etc.), bacterial infections of neighboring sites, neurologic disorders that impair sensation/tissue integrity of the treatment area, hematoma, osteoporosis, and pregnancy [7, 52].

All participants will sign informed consent and complete a health history questionnaire before being able to participate or be considered in the study. If participants have any of the relative or absolute contraindications or are experiencing adverse effected from IASTM or from massage therapy, they will be disqualified from the study.

Lastly, as part of inclusion criteria, female participants will have to be recruited from 4 days before their menses until 4 days after it [53]. Adkisson et al delineate the importance of standardization with the timing in vascular testing for women participants and their menstrual cycle phase when measuring blood pressure and blood flow in the research laboratory[53]. Two important points made in this study were: 1) systolic and diastolic pressures are decreased during Late Follicular and Early Luteal phase, 2) for VOP measures, the Late Follicular phase showed to be different when compared to the other 3 phases[53]. In conclusion, female participants will be able to participate if recruited when they are on the Early Follicular or Late Luteal phase [53].

Measurements and Instrumentation

Following is a description of the variables that will be measured for this study and the instrumentation that will be used for each.

Venous Occlusion Plethysmography (Hokanson)

This will be used to measure blood flow in the calf muscle for each participant in the study. Studies have shown VOP to have a high correlations ($r^2 \approx 0.8$) when compared to brachial artery electromagnetic flow probes during forearm exercise in a study by Longhurst and colleagues [43], $r^2 = 0.87 – 0.98$ between VOP and Doppler ultrasound with the brachial artery[43], $r = 0.86$ between Doppler ultrasound when measuring lower leg blood flow[45], and $r^2 = 0.85$ between the use of NMRI and VOP when measuring blood flow during post-ischemic reactive hyperemia[46].

Sphygmomanometer

A standard blood pressure cuff will be used measured to measure blood pressure cuff and a stethoscope prior to treatment to make sure that they are at resting state.

Standard Measuring Tape

A standard measuring tape will be used to measure the calf muscle's circumference to the nearest mm.

Skinfold Caliper (Harpenden)

A skinfold caliper will be used to measure skinfold (mm) at the greatest girth of the calf muscle.

Health History Questionnaire (HHQ)

The HHQ will consist of questions about the participant's demographics, lower extremity injuries, and specific questions covering any absolute or relative contraindications to IASTM or specific to Graston Technique, and/or massage therapy. The HHQ can be found in Appendix C.

Procedures

Participants will come in to the Research Lab in the Applied Medicine and Rehabilitation Services building at their scheduled time. They will be asked to wear athletic clothing that will allow complete exposure of their calf muscle. Oral explanation of the study and written information along with the informed consent will be presented to each participant. Each participant will read, complete and sign the Health History Questionnaire (HHQ, Appendix C) to determine if they are eligible to participate. If the participant is eligible to participate they will complete the informed consent. If they are not eligible their HHQ will be destroyed immediately.

Randomized Selection for Treatment Groups

Each participant will be randomly assigned a treatment order to either the receive Graston Technique treatment or to the massage therapy treatment during the first visit and then receive the other treatment on the second visit. This will be done by tossing a coin and assigning heads/tails to Head=GT or Tails= M. In a similar manner each participant's treatment leg will be randomly selected while the other leg will serve as the control leg (Head=Right; Tails=left). Each participant will be asked to return after a minimum of one week after the first treatment. On both sessions, the contralateral leg will be used as control. The treatment and control legs will be the opposite of those used during the first treatment session.

Blood Pressure and Pulse Measures

After selection of treatment group, the participant will be asked to lie on the treatment table and remain in a rested, quiet, and comfortable position for approximately 15 minutes. Their blood pressure and pulse will be taken just prior to the start of the rest period and every five minutes until two consecutive diastolic blood pressures measures are equal.

Pre-treatment VOP Measures

The participant will lie supine on the treatment table. One blood pressure cuff will be placed above the knee, and will be inflated below the participant's diastolic pressure for 5 seconds and then deflated in 5 seconds and repeated for 2 minutes. This allows blood to flow toward the limb tissue but does not allow it to flow back through the veins. Then, the strain gauge, in this case a silicone band, will be placed on the maximum gastrocnemius girth measuring the difference of limb volume in 5 seconds every 10 seconds within 2 minutes and will transform this data in millimeters of blood/100 ml of tissue/minute. An additional blood pressure cuff will be placed on the participant's ankle. The cuffs applied will be inflated above the participant's systolic pressure that will be taken in the previous step during rest. Baseline calf blood flow will be assessed for 2 minutes then the ankle cuff will be released and participant with rest for15 minutes. After the baseline-testing period, the participant will undergo either Graston Technique treatment or massage treatment that will be chosen at random as was detailed above. Participants will be asked to use a 100 mm Visual analog scale to monitor discomfort of the ankle cuff. They will mark their discomfort level on the scale and then it will be measured using a standard tape measure. If their discomfort rating is over 80, the cuff will be released.

Graston Technique

Graston Technique will be administered by a trained clinician on the participant's gastrocnemius as indicated by Graston Technique Instruction Manual by Therapy Care Resources. Appendix C provides details on the types of strokes and also specific details on the treatment method that will be used.

The pressure applied for the GT group will be the weight of the instrument. The speed of the strokes when using this instrument will be approximately 3 inches of tissue per second. For any of the strokes used, a linear path will be implemented starting near the origin of the gastrocnemius and working down to the most distal portion. Graston Treatment will last a total of 10 minutes per participant and will consist of four way directional sweeps, followed by fans, J-strokes and brushing strokes on any specific adhesions found. GISTM suggested sequence for the foot/ankle from the Graston Technique Instructions Manual will be used as a guide to perform this treatment.

Massage Therapy

Massage therapy will be performed by a massage therapy student with an average of 100 hours of clinical experience in therapeutic massage technique. The massage strokes that will be implemented are: effleurage and petrissage. These strokes are commonly chosen when the desired therapeutic effect is to aid in increasing blood flow to skin and muscle tissues in the patient. The massage treatment will involve the clinician's hands and a common emollient used by massage therapists.

Participants will assume a prone position on the treatment table with a bolster under the ankles. Effleurage massage will be performed on the participant's calf, which will consist of 30 strokes per min, and then petrissage with 50-60 strokes per minute. Massage treatment per participant will last a total of 10 minutes.

Post-treatment VOP Measures

Following either Graston Technique treatment or massage treatment, the blood flow measurements will be taken again in the following instances: immediately, 5-minutes, 20-

minutes, 40-minutes, and 60-minutes post-treatment. The same protocol and steps that were described for baseline blood flow will be taken for each individual post-treatment blood flow measure. The participant will be asked to rest in a comfortable supine position on the treatment table in the lab, and while they wait between each measurement, they will be allowed to quietly rest and watch a movie, show or program on a television screen.

Statistical Analysis

All data analyses will be performed using SPSS for Windows (version 16.0; SPSS Inc, Chicago, IL). A 2 way repeated-measures of analysis of variance will be used to assess changes in blood flow following Graston Technique treatment and massage therapy pre-treatment, immediately after treatment, and at 5 minutes, 20 minutes, 40 minutes, and 60 minutes post-treatment. We will use the Least Significance Difference (LSD) to adjust the degrees of freedom, and a α level of $\leq .05$ for the criterion for statistical significance.

Twenty participants between the ages of 18-35 will be recruited for this study. Sample size was calculated based on a power of 80% for reaching statistical significance ($p<0.05$) within and between techniques using G*Power 3.1.347 (Heinrich Heine University, Dusseldorf, Germany). Estimated means, standard deviations, and correlation coefficients were obtained from the literature[54]. The estimated sample size is 12 participants. We would need to recruit 20 participants to account for attrition and to reach statistical significance.

CHAPTER 4

MANUSCRIPT

Introduction

Instrument Assisted Soft Tissue Mobilization (IASTM) and massage therapy (MT) are manual techniques aimed at increasing blood flow to areas in the body treated by a clinician [1-8]. Many researchers and clinicians have investigated the effects of massage on blood flow but the results have been controversial and inconclusive [1-3, 9, 10]. In regards to IASTM, there are no studies on human subjects that have investigated the effect on blood flow.

IASTM is a manual therapy technique that has been around since the development of Gua Sha in 220BC, and uses instruments that are designed in a unique way to apply a force and detect soft tissue lesions during treatment [8, 11-13]. Massage is a manual therapy technique in which different strokes and hand motions are performed to achieve a therapeutic goal [9, 14-16]. These goals range from the increase in blood flow to tissues; helps in the prevention of blood clotting; reducing swelling; reducing discomfort associated with muscle spasms; improvements on flexibility; increased in skin and muscle temperature; and some beneficial effects in delayed onset muscle soreness (DOMS) [1, 14, 15, 27, 28]. IASTM and Massage Therapy techniques are used frequently to break down myofascial adhesions in the connective tissue in our body. These restrictions usually involve the adhesion of two structures together that do not allow normal fiber mobility and cellular or blood flow and circulation to occur [17-20]. Therefore by breaking down myofascial adhesions, theoretically blood flow is increased [6, 8, 17-20]. However, this clinical effect has yet to be determined.

The purpose of this research is: 1) to study the effects of Graston Technique and Massage therapy on calf blood flow post-treatment on the lower leg 2) to compare any differences in calf blood flow measures from the two treatment groups.

Methods

Participants

Twenty-eight healthy volunteers participated in the study (Age=23±3; Males=14/28 (50%); Females=14/28 (50%); Girth=39.5±4.3l; Skinfold=27.9±5.6). Participants were excluded if: they had any lower leg injuries for the past 6 months, possessed any absolute or relative contraindications for IASTM and massage therapy. All participants signed an informed consent and completed a health history questionnaire before participating. Every participant scheduled two visits that were a minimum of 3 days apart. The University's Institutional Review Board approved this study.

Procedures

Using a single-blinded prospective, longitudinal, controlled, repeated-measures design each participant attended their first session in which each was randomly assigned a treatment order to either the Graston Technique treatment or to the massage therapy treatment. In a similar manner each participant's treatment leg was randomly selected while the other leg will serve as the control leg. Each participant was asked to return after a minimum of 3 days after the first treatment. On both sessions, the contralateral leg will was used as control. On the first visit, participant's calf skin fold and calf girth measurements were taken for both legs. Skin fold was taken using a Harpenden skinfold caliper, and the calf muscle's greatest girth was measured to the nearest millimeter. Calf Girth measurements were taken using a standard measuring tape and also to the nearest millimeter. For both skin fold and girth measurements, participants were in a seated position on a stool with both feet on the ground, their knees relaxed and at approximately 90 degrees of flexion. Every participant was barefoot and measurements were taken 3 times and the average value was calculated and recorded.

For each visit, participants pulse and blood pressure was taken to make sure we began treatment at resting values. A standard blood pressure cuff and stethoscope was used for blood pressure measurements. Participants rested prone on a treatment table and the calf area was cleaned with an alcohol pad. Skin temperature values were taken for both legs by placing a wireless VitalSense dermal temperature patch on a mid point of the gastrocnemius on each leg. Using the VitalSense monitor we activated each new VitalSense dermal temperature patch. Every dermal temperature patches had a unique ID number and an internal battery. We tracked and recorded skin temperature data for approximately every 5 minutes per patch. After the baseline skin temperature value was recorded, the patch was removed and a ten-minute treatment (Massage or Graston Technique) was performed on the randomly chosen leg. The participant's calf was cleaned with a towel to remove the emollient and the skin temperature patch was placed again on the mid calf section. Skin temperature measures were taken immediately after treatment and every 5 minutes for a total of 60 minutes post treatment. The first session was concluded after the 60-minute post-treatment measurement. During the second data collection session, the treatment and control legs were the opposite of those used during the first treatment session.

Figure 1. Methods Flowchart

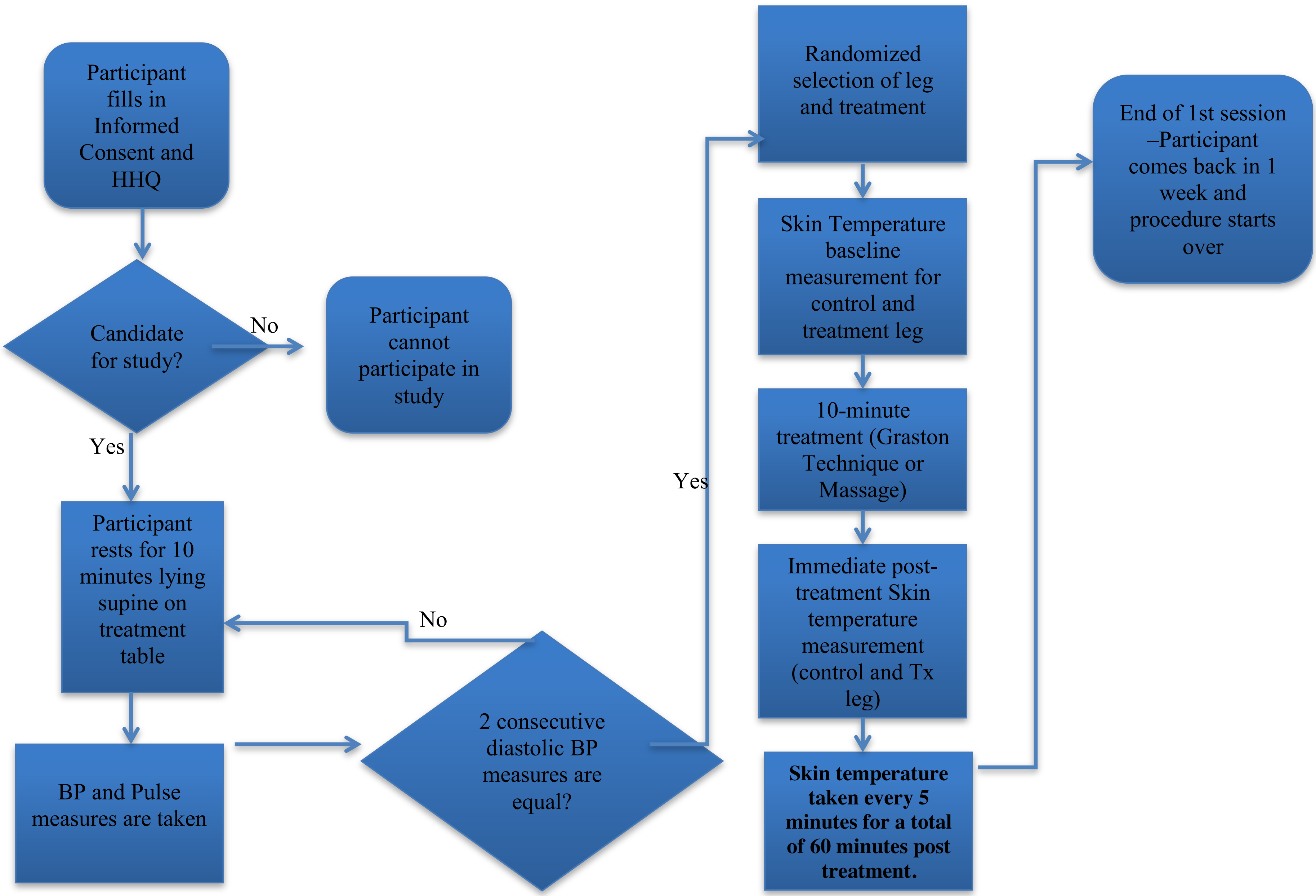
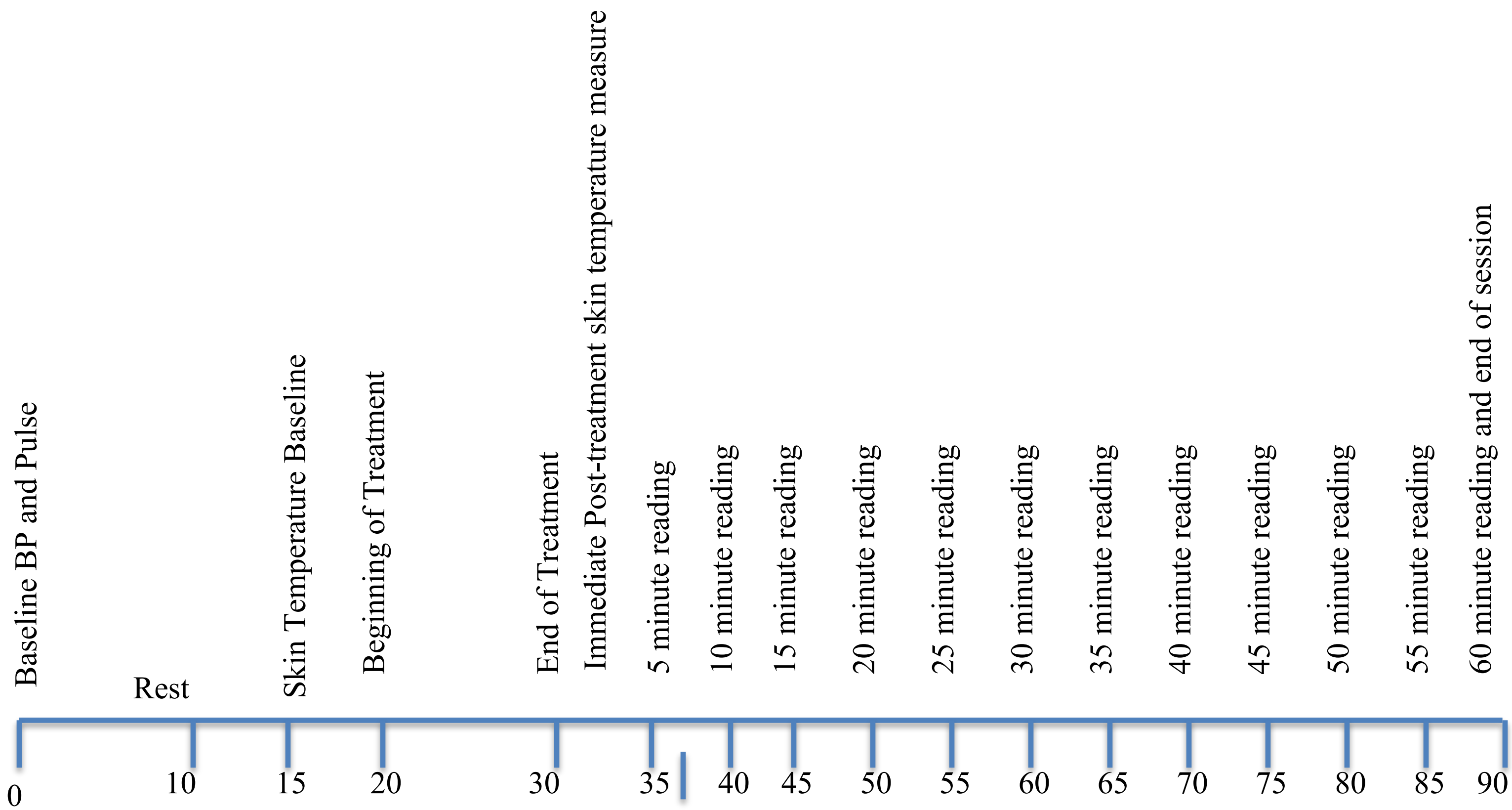


Figure 2. Procedures Timeline



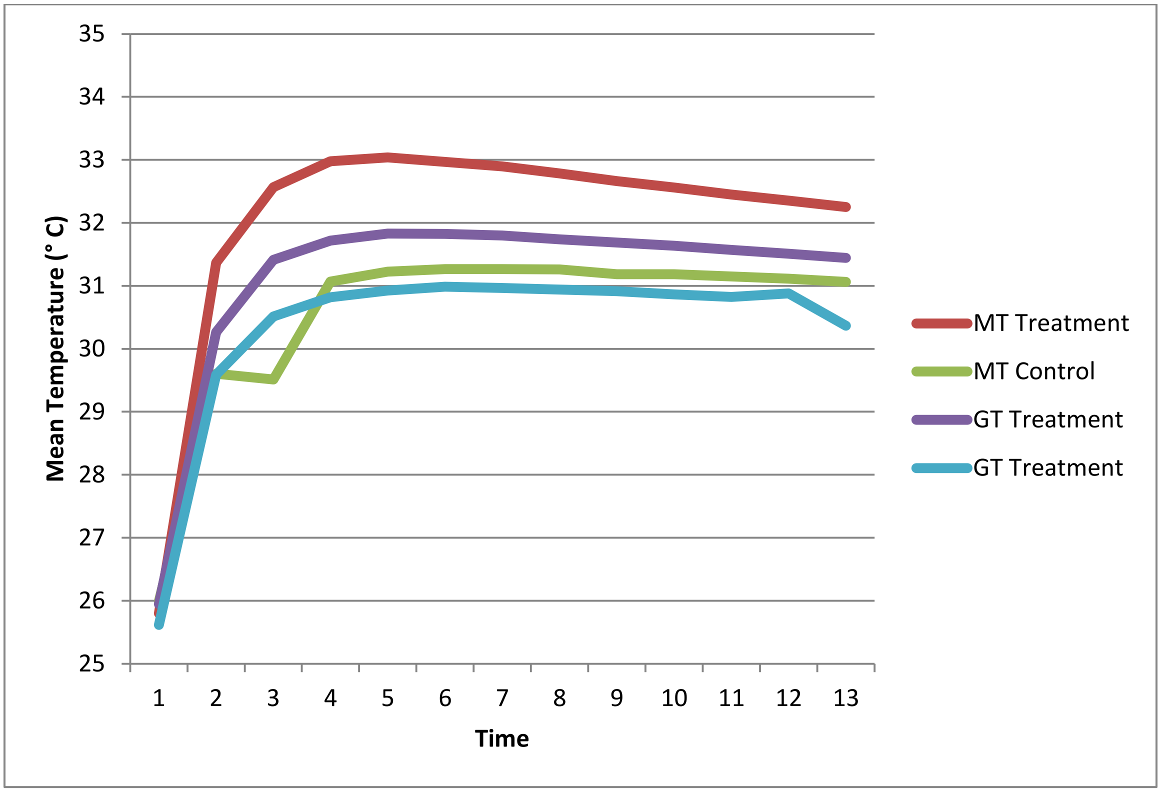
Statistical Analysis

We measured baseline skin temperature on the calf prior to treatment, and again every 5-min after treatment for a total of 60-min. We evaluated differences between conditions (4) and time (13) with a repeated measures ANOVA. Significance was set at $p<0.05$ a-priori.

Results

We identified significant differences with Greenhouse-Geisser corrections between conditions ($F_{2.4,61.2}=39.252$, $p<0.001$, ES=0.602) and time ($F_{2.1,54.4}=192.8$, $p<0.001$, ES=0.881), but failed to achieve a significant main effect ($F_{2.1,53.5}=2.944$, $p=0.060$, $1-\beta=0.558$). The massage condition (32.05±0.16°C) yielded significantly higher skin temperatures as compared to the massage control (30.53±0.14°C, $p<0.001$), GT (31.11±0.20, $p<0.001$), and GT control (30.32±0.14,$p<0.001$) conditions. Only the control conditions were not significantly different from one another ($p=0.189$). We also identified significant differences in time, whereas the baseline (25.83±0.30°C) acquired prior to treatment was significantly lower than all other temperature measurements ($p<0.001$). Moreover, temperatures at 5-min (30.21±0.12°C), 10-min (31.00±0.30°C), and 15-min (31.65±0.12°C) showed significant increases ($p<0.001$). After 15-min, the skin temperatures continued to rise and each time point was statistically different from the baseline and up to the 25-min peak temperature (31.76±0.12°C), but these differences were not clinically significant differences (<0.80°C)[55].

Figure 3. Comparison of Mean Skin Temperature and Treatment Conditions Over Time



Discussion

This study demonstrated that massage and GT increase skin temperature. A rise in skin temperature theoretically indicates an increase in blood flow to the area. Massage had a higher temperature increase when compared to GT, but both techniques increased temperature consistently for up to 25min post treatment. The key finding of this study was that the MT condition produced clinically significant, higher skin temperatures when compared to MT control, GT condition, and GT control. Important significant changes were found between GT condition and GT control. These results suggest that a 10-minute MT and GT treatment can increase skin temperature and peripheral blood flow to areas receiving treatment and surrounding areas. For both GT and MT, the changes in skin temperature were found to increase immediately after treatment and continued to increase and peaked at 25 minutes post treatment. Skin temperatures never returned to baseline after 60 minutes of data collection. They remained between 5 and 6 degrees higher than pretreatment temperatures in all conditions.

The MT control and GT control did not differ significantly from one another and even though treatment was not directly applied, both increased in temperature immediately alongside the treatment leg. The massage treatment legs (33.041°C±0.179) caused a 1.77°C (5.4%) increase in skin temperature difference from the massage condition legs (31.267°C±.129). The GT treatment legs (31.831°C±0.205) caused a 0.84°C (2.6%) increase in skin temperature difference from the GT condition (30.988°C±0.139). The changes and increase in temperatures for the control legs were not a result of heat conducted directly from the massage therapist hands or the GT instruments to the leg, but instead suggest an increase in blood flow and peripheral perfusion to surrounding areas and the opposite limb from the one treated. According to Goats, G. when massage or connective tissue massage is applied to one limb, blood flow will increase on the other one due to a manual stimulation and triggering of cutaneovisceral reflexes that cause vasodilation [14]. Goats G. and Barr et. al suggest an effect and activity on the sympathetic autonomic system and physiological effects that are independent of any change in blood flow occurring on the opposite limb and areas surrounding the treatment site [56, 57]. Exploration of these physiological effects warrants further research.

In a study by Loghmani et al, researchers studied the effects of IASTM on tissue level healing on rodent's MCL injuries [37]. GT was performed 1-week post injury for 3 sessions a week for a total of 3 weeks. Laser Doppler was used to take perfusion images of the ligaments and study the effects of healing and collagen formation [37]. No significant changes were found for 5,10, 15, and 20 minutes post-treatment, but a significant change was found 24 hours post-treatment and 1-week post final treatment session [37]. These results did not measure skin temperature like in our current study, however results demonstrated a change in collagen fibers and healing which suggest an increase in blood flow to the treated areas with GT.

A number of studies have attempted researching the effects of blood flow after massage, but there are many controversial outcomes that have already been explored in previous literature reviews [1-3, 9, 10, 29]. The biggest challenge in all of the research on massage and its effect on blood flow is the different measurement methods. When the effects of massage and light touch on skin temperature were investigated, the researchers measured skin temperature changes using Dynamic Infrared Thermography (DIRT) in the neck and shoulders [1]. The results paralleled ours in that they saw similar patterns in the rise of skin temperature; with 20 minute MT increasing temperature over time to the areas treated and areas adjacent as well [1]. The skin temperature changes were significant for the MT group when compared to control and light touch groups. The peak temperature time for increased temperature was 35 minutes post treatment [1]. In a study using thermistor probes placed in the vastus lateralis to evaluate three different massage conditions (5 min, 10 min, and 20 min) and a 5-minute ultrasound treatment [58]. Their findings demonstrated that the probes embedded 1.5 and 2.5 cm deep led to a significant greater temperature change when compared to the 5-minute ultrasound treatment ($p<0.002$) [58].

Limitations

Limitations of the study include using skin temperature as an indirect measure of peripheral blood flow. Our findings are all measures of skin temperature post treatment and suggest blood flow is increasing in the area treated. However, we do not know the depth in tissue that this change is occurring. Future research is needed to study the effects of MT and GT on blood flow during treatment, as well as studies to conclude how deep this temperature and blood flow increase is occurring in the muscle tissue.

Conclusion

This study demonstrated that a 10-minute massage and GT treatment increase skin temperature on the body part being treated. A rise in temperature theoretically indicates an increase in blood flow to the area. An increase in blood flow stimulates nutrients and oxygen to tissues in the body, as well as increase of tissue mobility and increase of muscle flexibility. Massage had a higher temperature increase when compared to GT, but both techniques increased temperature consistently for up to 25 minutes post treatment. Further research is needed to conclude how deep this temperature and blood flow increase is occurring in the muscle tissue. Potential future research ideas could involve comparing GT and MT techniques compared to active warm up or other passive methods such as a moist heat pack. From our study we can conclude that if a clinician’s therapeutic goal is to increase temperature and blood flow, both massage and GT would be good treatment choices with massage yielding significantly higher temperature and blood flow.

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APPENDIX A: SUMMARY OF MASSAGE AND ITS EFFECTS ON BLOOD FLOW

Title/Author	Purpose of study	Methods	Results	Conclusions
Effects on Massage and Limb and Skin Blood Flow after Quadriceps Exercise Hinds et al [3].	Massage resting control condition upon femoral artery flow (FABF), skin blood flow (SKBF), skin (SKT), and muscle (MT) temperature after dynamic quadriceps exercise	- 13 males - Repeated measures design, within subjects experimental design with counter-balanced design - Femoral artery blood flow was measured using Ultrasound Doppler system. Skin Blood flow was measured with Laser Doppler flowmetry. - Blood flow, muscle temperature made pre- and post exercise, middle and end of recovery (massage or rest) period - 3x2 min concentric quadriceps exercise - 2x6 min bouts of deep effleurage and petrissage massage or a control (rest) period of similar duration	- FABF increased from rest to post exercise in both trials, it then returned to baseline - No significant differences in FABF between trials during of after the massage/rest - SKBF data was similar at both sites in each trial. SKBF was elevated in the massage trial.	- Massage did not increase femoral artery blood flow, blood lactate, blood pressure, or heart rate when comparing it to control group - Skin blood flow and temperature did increased after massage when comparing it to control group

Effects of Massage on Blood Flow and Muscle Fatigue Following Isometric Lumbar Exercise Mori et al [2]	To investigate the influence of massage on the skin and the intramuscular circulatory change associated with localized muscle fatigue	- 29 male subjects - Two experimental sessions separated by more than one week - 15 subjects received massage, and rest in the second session, 14 received intervention in the reverse order - They performed an isometric lumbar extension (90 second hold), then received massage or rested for 5 minutes, then did the same isometric extension for a second time - Muscle blood volume (MBV) and skin blood flow (SBF) were measured with a laser blood flow meter and near infrared spectroscopy (NIRS) - MBV were recorded before and after the loads (for 60 seconds) on right paraspinal muscle	- MBV= $F(3,84)=3.7$, $p<0.05$. - MBV showed an increase at post-load II period with the massage condition group - MBV also increased between pre- and post-load II after massage than after rest - SBF also increased at pre- and post-load II under the massage conditions, and increased between post-load I and pre-load II during massage - Skin temperature was higher under massage conditions than under rest, $t(28) = 8.13$, $p<0.0005$	- Results show MBV increase after load II under massage condition, and an increase in MBV between pre- and post-load II being higher in massage condition than rest - Rest was used as a control condition, meaning that it cannot be concluded if the changes that happened were truly because of the massage and not because of the isometric exercise that the subjects performed. - The difference between massage and control MBV was not very significant, and the degree of skin temperature was also very small (0.45 C increase from post-load I to post-load II)

		- Skin temperature continually measured with a thermography		
Massage impairs postexercise muscle blood flow and "lactic acid" removal Wiltshire et al [9]	To test the hypothesis that sports massage helps muscle recovery from exercise by increasing muscle blood flow to improve “lactic acid” removal	- 12 male subjects, 3 experimental conditions performed on same day with order counterbalanced - Each subject performed 3 maximum voluntary contraction (MVC) by doing maximal isometric handgrip (IHG) contractions (2 min hold) with a calibrated handgrip dynamometer (1 min between interval) - Post- IGH passive recovery for 10.5 minutes - Post-IHG active recovery for 30 seconds and then 10 min of rhythmic forearm contractions at 10% MVC at a duty cycle of 1;2-s contraction-relaxation	- **Brachial artery blood velocity profile**: passive rest conditions showed uninterrupted pulsatile flow; for the rhythmic 10% MVC contractions there was a negative brachial artery blood velocity; with effleurage and petrissage there was consistent retrograde flow with each stroke followed by increase in blood flow velocity during the brief pauses - **Forearm blood flow (FBF):** Baseline no different between conditions; FBF decreased in massage recovery vs. passive recovery for the first 3.5 minutes post-IHG ($p<0.012$) and decreased in active recovery vs. passive recovery for the first	- Authors’ major findings: massage and active recovery resulted in rhythmic retrograde brachial artery flow post-IHG exercise, and FBF posst-IHG exercise was significantly decreased during massage recovery and during active recovery compared with passive recovery - Authors’ conclusion is that sports massage severely impairs blood flow during massage stroke, and this therefore has a net effect of degreasing muscle blood flow early in the recovery period after strenuous exercise, they concluded similar effects happen with the active recovery group.

		- Post- IHG massage for 30 seconds, and then effleurage massage to forearm 2.5 min intervals and petrissage during 5 min period in between. - Brachial artery mean blood velocity and diameter (MBV) was measured with pulsed-doppler ultrasound probe, freq of 4 MHz, at the brachial artery.	1.5 min post-IHG (p<0.013); FBF increased in active recovery vs. massage recovery at 1.5-2.5 min post-IHG, and no statistical significant differences between recovery conditions after 4.5 min post-IHG - Active recovery no different from passive recovery (p=0.217)	
Effleurage Massage, Muscle Blood Flow and Long-Term Post-Exercise Strength Recovery Tiidus and Shoemaker [29]	To assess the effects of effleurage massage on long term strength recovery, and DOMS sensation following intense eccentric quadriceps muscle work	- 9 subjects (5 female, 4 male) - Isometric and dynamic knee extension peak torques, and maximum voluntary contractions (MVC) were determined - 3 days later subjects did eccentric work set: 7 sets of 20 consecutive quadriceps muscle group MVCs - Random selection of	- No significant difference on femoral artery mean blood velocity (MBV) massage on day 1 (1 hour post-exercise) and day 4 (72 hours post exercise) - Femoral vein MBV during massage was not different from rest condition - No significant difference between femoral artery vein MBV on day 4	- Deep and superficial Effleurage massage on the quadriceps had no effect on femoral artery or vein MBV - Light quadriceps contractions improved blood flow more than the massage technique

		leg for massage group - Massage: superficial and deep effleurage strokes, repeated on days 2-4 - Duration of massage was not controlled, no mention of how long this lasted per subject - Mean arterial and venous blood velocity (MBV) on the femoral artery measured with Doppler ultrasound velocimetry - MBV of massaged leg measured on day 1 and 4; resting MBV collected 20-30 min of supine rest and during minutes 0-1, 4-5, and 9-10 of massage		
Failure of manual massage to alter limb blood flow: measured by Doppler ultrasound	Size of the muscle mass being massaged and its influence on blood flow response. Types	- 10 subjects, experimental design - Effleurage (30 strokes per min), petrissage (50-60 strokes per min) and	- MBV Forearm/brachial artery for massage treatment group was variable at the onset of massage but not	- Results of this study showed that differences in muscle mass or massage techniques do not elevate total limb blood flow.

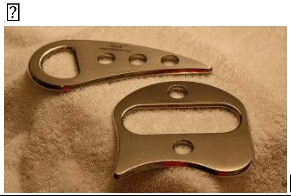
Shoemaker et. al. [42]	of massage tested: effleurage, petrissage, and tapotement	tapotement (360 percussions per min), all 3 lasted 5 min w 5 min of rest between treatment, done on both the right forearm and quadriceps muscle - Mild isometric handrgrip contraction over 2-s period, unweighted knee extension for 2-s period - Arterial MBV measured with Doppler ultrasound continuously for 30 s at rest, during contraction, and for 30 s of post-contraction flow response; brachial and femoral artery diameters measured w echo Doppler at beginning and end of treatment	different from the rest/control group - Brachial artery diameter at rest also did not change for the 3 massage techniques; massage had no effect on forearm blood flow during treatment - Voluntary handgrip contraction caused increase MBV, a significant value compared to rest (15.2 cm-s $^{-1}$) - Quadriceps/Femoral artery had similar responses to those of forearm. Massage values were not different than those at rest, and resting femoral artery diameter a was also not altered by the massage	
Therapeutic massage of the neck and shoulders	To determine effect of therapeutic massage on	- Seventeen (17) (8 males/9 females) - Blinded, randomized, crossover design:	- Both IAUC and adjusted post-treatment averages (mean C), the massage	- Researchers concluded that they found higher skin temperatures when compared to control.

produces changes in peripheral blood flow when assessed with dynamic infrared thermography Sefton et al [1]	peripheral blood flow (used a Dynamic Infrared Thermography (DIRT))	Control (c), light touch (LT), massage (MT) conditions on 3 separate days, at least 1 week apart - **Control (C)**: subjects rested quietly - **Light-Touch (LT):** massage therapist lightly placed the hands in contact with the skin without using massage strokes or pressure - **Massage condition (MT):** 20 minute protocol, combination: effleurage, pretrissage, Z-strokes, passive stretches to general neck/shoulder areas: T3-C1, erector spinae, upper trapezius, Levator scapula, scalenes. - **DIRT**: thermal images pretreatment, immediate-post, 15, 30, 45, and 60 minutes postmassage	condition produced significant elevations in temperature in five regions when compared to control condition: Zone 1(anterior upper chest, IAUC p-0.02, C p=0.04); zone 7 (posterior neck, IAUC p= 0.0002, C p= 0.0006); zone 8 (upper back, IAUC p=0.004, C p=0.0005); zone 9 (posterior right arm, IAUC p=0.02, C p=0.03); and zone 13 (middle back, IAUC p=0.02, C p=0.02) - LT compared to C, no significant changes found - MT compared to C, found significant elevations in temperature in zones 1, 7, 8, 9, and 13	They claim that this suggests that a 20 minute MT protocol can increase skin temperature and peripheral blood perfusion to both the areas receiving massage areas and also areas adjacent to treatment area. - Things to take into account is the fact that DIRT is still an indirect measure of peripheral blood flow, and that this blood flow is not peripheral blood measure at muscle depth.

APPENDIX B: SUMMARY OF IASTM TOOLS[35]

IASTM tools	Year of Development	Composition	Description	Training	Cost
FAST 	2010	Composite metal injected plastic (heavier than aluminum and lighter than steel)	2 instruments: F1 (12oz) and the F2 (4.6oz)	No training available.	$447.00
Graston Technique 	1994	Stainless steel	6 instruments in a set. Each is comprised of convex/concave surfaces to mold to various contours of the body.	Module 1 Basic Training Module 2 Advanced Training Module 2 Advanced/Upper (Occupational Therapist or Certified Hand Therapist only)	Module 1 Basic Training: $495.00 Module 2 Advanced Training: $695.00 Module 2 Advanced/Upper Quadrant: $450.00 $2,755.00 full instrument set $2,150.00 for OT/CHT instrument set
St3 Fuzion 	N/A	Aerospace aluminum (Fuzion I) or a polymer, mineral filled model (Fuzion II) depending on the design.	Designed to be an all-in-one multi technique tool. The Fuzion II is much lighter in weight compared to the Fuzion 1. Both models come in sizes small to extra large.	Do not need training to purchase. Training workshops and online training and forums are available. A fundamental instructional video and hand position manual are included with all purchases.	Fuzion I: $1,295.00 Fuzion II: $475.00 Fuzion II Pink Demo: $450.00 All sizes (small-extra large) are priced the same

IASTM tools	**Year of Development**	**Composition**	**Description**	**Training**	**Cost**
IAM tools (Instrument-Assisted Massage)     	2010	Grade 315 stainless steel	6 tools in total consisting of non-beveled and single and double beveled edges. Each tool is individually hand-crafted.	Do not need training to purchase. 3 hour training seminars are offered.	Training seminars are approximately $80.00. Dolphin: $554.00 Seahorse: $438.00 Seal: $524.00 Can Opener: $469.00 2 in 1: $312.00 Fin: $453.00
Ellipse 	2011	Stainless Steel	All-in-one tool. Double beveled	No training required or offered for purchase or use of the tool.	$199.00

IASTM tools	Year of Development	Composition	Description	Training	Cost
FAKTR-PM (Functional and Kinetic Treatment with Rehab, Provocation and Motion) 	N/A	Stainless Steel	All edges are double beveled. F1: 6 5/8" long by 1 ½" high. Weighs 7oz. F2: 8 3/8" long by 1 3/8" high. Weighs 8oz. F3: 8" long and 1 ½" high. Weighs 7oz. F4: 7 ¾" long and 1 7/8" high. Weighs 6oz.	FAKTR is a concept, not a technique. Therefore, the training program is extensive and teaches clinicians IASTM as well as other techniques. No training required for purchase of tools.	Classes are $475.00. College Faculty and Student rate of $420.00 Individual Instruments are $295.00 Full set of 4 instruments: $999.00
BioEdge 		Stainless Steel	All-in-one instrument consisting of 3 different contoured edges. Weighs 14.8oz and measures 9.5" in length	No training required for purchase. Information video provided on company website.	$425.00
Fibroblaster/Jack 	Developed in 2009 On the market in 2010	Stainless Steel	Fibroblaster: 4" in length and 4" in width. Weighs 8oz. Single beveled edge. Jack: 6" in length and 2 ½" in width	No training or certification required for purchase. No specific training offered.	Fibroblaster: $125.00 Jack: $125.00 Set: $230.00 Student discount: $75.00

IASTM tools	**Year of Development**	**Composition**	**Description**	**Training**	**Cost**
SASTM (Sound Assisted Soft Tissue Mobilization) 	2000	Aerospace ceramic polymer	The 8 instruments are designed on a square surface as opposed to a convex/concave instrument.	Certification required for purchase of instruments. Can be done either online prior to attending a seminar by completing an online test, or by attending a seminar and then purchasing instruments.	Purchase of instruments includes certification. Additional certifications require either $250.00 per clinician or the attendance of a seminar for $500.00. $2500 for all 8 instruments.
Narson body Mechanic N6	2006	Stainless Steel or Delrin Plastic	All-in-one instrument with convex, concave, and flat edges. Textured grip.	NO training required for purchase. No specific training offered.	Stainless Steel model: $465.00 Delrin Plastic model: $195.00 Left handed versions available: add $25.00
Scimitar Tools 	2009	Stainless Steel or Aluminum	All-in-one tool. 6 different radius sizes 7.375" long 1.375" wide 3/16" thick Stainless Steel: 4oz Aluminum: 1.74oz	No training or certification required for purchase. No specific training offered.	Stainless Steel: $259.00 Aluminum: $179.00

IASTM tools	**Year of Development**	**Composition**	**Description**	**Training**	**Cost**
The Edge 	2012	300 grade stainless steel	All-in-one tool Multiple edges- some sharper than others	Upper and lower body instructional DVD (1 hour)	$110.00 Student discount available
Myo-Bar   	Developed in 2001 On the market in 2011	Stainless Steel	Tools feature parabolic radius edges. They also feature both single and double bevel edges.	Currently developing a DVD and workshops. A detailed Technique Primer with IASTM background, research and 10 technique stroke descriptions is included for all orders.	Healing Edge 1+: $79.00 Healing Edge 1: $75.00 Healing Edge II+: $135.00 Healing Edge II: $95.00 Scar Tissue Release Detail Tool: $75.00 Fascia Bar: $75.00 Cyriax Friction Tool: $75.00 Trigger Point Tool: $35.00
Healer's Friend 	2005	Stainless Steel	All-in-one instrument with convex and concave edges.	No training or certification required for purchase. No specific training offered.	$399.00

IASTM tools	Year of Development	Composition	Description	Training	Cost
Tecnica Gavilan 	2006	Stainless steel	3 different instruments: Ala, Garra, and Pico. Each instrument has both concave and convex surfaces that are all double beveled.	Offers a 6-hour course to teach safe application of IASTM. Instruments are only sold to practitioners who have passed a course in IASTM (Tecnica Gavilan, FAKTR, Graston Technique, SASTM or ASTYM)	Working including instrument set: $795.00 Workshop only: $185.00 Set of instruments: $750.00 Student price: $595.00
Miyodac therapy 	2012	Stainless steel	7 different instruments or various sizes, treatment edges and weights.	No training or certification required for purchase. No specific training offered.	Achilles tool: $479.20 Blade tool: $477.20 Pen tool: $319.20 Star tool: $527.20 Trigger tool: $479.20 Trigone tool: $423.20 Wave tool: $367.20 Complete set: $1395.00
Adhesion Breakers 	2012	Stainless steel	5 different tools comprised of convex and concave edges.	No training course required or offered.	AB1: $185.00 AB2: $170.00 AB3: $165.00 AB4: $160.00 AB5: $160.00 Complete set: $600.00

IASTM Tools	**Year of Development**	**Composition**	**Description**	**Training**	**Cost**
i-assist tools 	N/A	316 grade stainless steel	All-in-one tool with convex and concave treatment edges. There is a distinct hook as well as flat edges and ridges. Matte textured surfaces exist in areas intended for grip.	No training or certification required for purchase. Workshop and background informational courses are being developed.	$450.00
ASTYM 	1995	Polymer-resin composite	3 instruments that vary in shape, size, and treatment edges.	Must be certified in the technique in order to purchase instruments.	Per clinician over-time program: course $995.00/clinician, $360.00/instrument set, subscription fee is 10 annual payments of $700.00/clinician Per clinician one-time program: $5000.00/clinician, instruments and subscription included Per site program: certification is $995.00/clinician, instrument set is $360.00, subscription is $2000.00/year

APPENDIX C: HEALTH HISTORY QUESTIONNAIRE

Please answer the following questions, and notify the researcher of any questions or for further explanations to any of the questions on this questionnaire or the study.

1. What is your age? ____

2. Do you currently have, or have had in the past 6 months, any injuries to your lower extremity? (i.e. knees, calf, ankle, or foot?) Circle one.

YES NO

3. Please check any conditions that apply to you:

Red Flags/Absolute contraindications:

☐Open wound- unhealed suture site/sutures

☐Unhealed fractures

☐Thrombophlebitis

☐Uncontrolled hypertension

☐Kidney Dysfunction

☐Patient intolerance/Non-compliance/Hypersensitivity

☐Hematoma

☐Osteomyelitis

☐Myositis Ossificans

Yellow Flags/Relative contraindications:

☐Anti-Coagulant Medications

☐Cancer

☐Varicose Veins

☐Burn Scars

☐Acute Inflammatory Conditions (e.g. Synovitis)

☐Inflammatory Conditions Secondary to Infection

☐Rheumatoid Arthritis

☐Pregnancy (consider inherent ligament laxity)

☐Osteoporosis

4. Are you allergic or have any allergic reactions to mineral oil or beeswax? Circle one.

YES NO

5. Are you currently taking any medications such as: anti-coagulants, steroids, hormone replacement therapy, birth control?

YES NO

Female Health Questionnaire:

1. Are you pregnant?

YES NO

2. Please indicate the last date of your menstrual cycle? _______________

3. Do you have a regular menstrual cycle?

YES NO

APPENDIX D: GRASTON TECHNIQUE TREATMENT AS DELINIEATED BY THERAPYCARE RESOURCES[7]

Treatment Method and General Principles:

Work with instruments in the following manner during the evaluation and treatment process:

General	To	Specific
Superficial	To	Deep
Start Centrally	Move Peripherally	Back to Center
Non-Aggressive	To	Aggressive

Treat all aspects of the joint

Medial	To	Lateral
Anterior	To	Posterior
Superior	To	Inferior

Treatment Parameters

Consider the following treatment parameters relevant to the patient's condition, therapeutic goals and desired treatment response.

Preparation:

Before beginning treatment, secure the needed materials.

Instruments: Select the appropriate instruments/

Lubricant: Emollient is used to decrease friction between the surface of the skin and the instruments. Apply the lubricant on the patient's skin with your hands, not with an instrument. By using your hands, it allows you to assess tissue temperature, swelling and condition.

Alcohol: used to remove lubricant from the clinician's hands and patient's skin after treatment. Alcohol is not adequate to disinfect the instruments and does not meet OSHA standards. Wash/disinfect your hands after each treatment.

Disinfectant: use a qualified disinfectant to clean the instruments, such as a Cavicide or Envirocide.

Clinician Position:

The clinician should be in a relaxed position. Maintain good posture.

Align the direction of the forearm with the direction of treatment force. This reduces the clinician's energy expenditure and increases treatment accuracy.

Patient Position:

The patient should be in a relaxed, comfortable position. The body part being treated should be appropriately supported. This reduces muscle activity, which allows for more effective treatment. Minimize the need to change the patient position and assure proper draping.

*For this study patient will be lying prone on the table with lower leg and calf being treated exposed.

Angle of Application:
The angle of application is the angle at which the treatment edge of the instrument is applied to the body part. For maximum fiber separation and contouring of the instrument to the body shape, a 30-60 degree angle of application is recommended.

Rate:
The stroke rate is the same as the stroke velocity. Reduce the stroke rate over larger areas to improve patient comfort. Patients can tolerate quicker, shorter strokes in smaller areas. Reduce the rate when higher pain levels exist.

Duration:
GISTM session: Usually around 8-10 minutes for treatment of all involved regions. *For this study we will have a controlled time of 10 minutes of GISTM treatment per participant.

GISTM SUGGESTED SEQUENCE-FOOT/ANKLE

Patient Position: Prone, foot over end of treatment table
Clinician Position: Standing or sitting
Instruments: GT-4 and GT-5
Grip: Two hand hold
Technique: Sweep and fan the gastroc-soleous complex, starting proximal to the Achilles tendon insertion up to the popliteal fossa using GT-5. Assess with the ankle in neutral position and in dorsiflexion to vary the tension of the tissue as it affects the instrument's depth of penetration
Instruments: GT-3
Grip: Pencil grip
Technique: Localize any restrictions within the gastroc-soleous complex and Achilles tendon.

APPENDIX E: RAW DATA

Participant	Age	Gender	LGirth	RGirth	LSkinFold	RSkinFold	meangirth	meanskinfold
9	23	1	42.0	42.0	30	30	42.00	30.00
10	22	1	43.4	43.5	28	29	43.45	28.50
21	23	1	38.0	38.0	26	26	38.00	26.00
43	25	2	39.5	40.0	26	25	39.75	25.50
39	19	2	29.5	29.0	16	18	29.25	17.00
81	25	2	34.5	34.0	24	23	34.25	23.50
86	24	2	36.5	37.0	18	13	36.75	15.50
13	23	1	47.5	47.5	25	25	47.50	25.00
5	23	2	41.0	42.0	32	33	41.50	32.50
64	23	1	39.0	39.0	30	29	39.00	29.50
73	22	2	40.5	35.0	24	22	37.75	23.00
23	20	2	36.5	36.5	28	30	36.50	29.00
32	26	1	46.0	45.5	24	23	45.75	23.50
7	23	2	36.0	36.0	26	25	36.00	25.50
66	21	2	35.0	35.5	29	29	35.25	29.00
28	23	1	32.0	31.5	26	27	31.75	26.50
27	21	2	38.0	36.5	31	30	37.25	30.50
3	23	1	44.0	43.5	24	24	43.75	24.00
94	24	2	44.0	43.0	25	24	43.50	24.50
62	24	1	36.5	38.3	20	21	37.40	20.50
39	32	2	45.0	45.0	36	35	45.00	35.50
82	23	1	42.5	42.5	32	30	42.50	31.00
81	27	1	37.0	37.2	33	32	37.10	32.50
4	22	1	45.5	45.8	34	36	45.65	35.00
66	19	2	39.0	39.4	31	31	39.20	31.00
44	21	1	40.0	40.5	40	37	40.25	38.50
2	23	1	41.5	41.5	38	38	41.50	38.00
56	20	2	38.5	38.0	30	30	38.25	30.00

Participant	MBaseline	M5min	M10min	M15min	M20min	M25min	M30min
9	30.28	32.22	32.72	32.58	33.38	33.33	33.24
10	22.91	31.04	32.55	32.90	32.96	32.97	33.01
21	24.75	32.55	33.14	33.35	33.53	33.57	33.45
43	26.60	31.98	33.12	33.28	33.18	32.90	32.74
39	27.19	32.03	32.05	34.04	34.11	34.11	34.13
81	25.16	31.10	32.24	32.54	32.52	32.40	32.12
86	27.77	32.14	32.94	33.02	33.01	32.99	32.92
13	25.70	32.61	33.90	34.05	34.00	33.87	33.83
5	28.78	31.86	33.22	33.70	33.79	33.63	33.54
64	23.87	30.76	32.12	32.32	32.45	32.36	32.37
73	25.65	31.75	33.21	33.35	33.13	32.79	32.54
23	24.21	31.43	33.34	33.46	33.40	33.15	33.01
32	26.07	30.86	32.24	32.69	32.72	32.71	32.75
7	26.67	31.64	31.51	33.86	33.84	33.69	33.56
66	25.34	31.70	33.60	33.97	34.05	34.03	33.92
28	23.71	30.88	32.03	32.32	32.40	32.27	32.24
27	23.37	31.36	32.73	32.98	33.19	33.03	33.11
3	25.88	30.95	32.71	33.41	33.60	33.69	33.75
94	23.68	31.11	32.19	32.23	32.19	32.04	31.83
62	25.25	30.20	31.38	31.66	31.67	31.56	31.51
39							
82	27.21	31.41	32.68	33.01	33.09	33.14	33.11
81	23.62	29.76	31.04	31.29	31.37	31.37	31.30
4	28.76	30.13	30.21	30.21	30.21	30.21	30.22
66	26.60	31.60	33.48	33.91	33.85	33.79	33.55
44	26.67	31.85	33.85	34.39	34.45	34.53	34.60
2	25.81	31.22	33.11	33.33	33.39	33.27	33.21
56	25.01	30.78	31.95	32.49	32.63	32.73	32.71

Participant	M35min	M40min	M45min	M50min	M55min	M60min
9	33.07	32.93	32.75	32.57	32.51	32.42
10	32.91	32.90	32.89	32.80	32.69	32.55
21	33.36	33.25	33.16	33.07	32.92	32.73
43	32.61	32.42	32.25	31.93	31.95	31.87
39	34.07	33.91	33.72	33.60	33.52	33.40
81	31.97	31.78	31.69	31.55	31.51	31.35
86	32.70	32.55	32.49	32.41	32.34	32.29
13	33.66	33.58	33.42	33.36	33.30	33.14
5	33.42	33.29	33.16	32.94	32.92	32.87
64	32.30	32.10	31.83	31.89	31.86	31.63
73	32.26	31.99	31.88	31.66	31.48	31.34
23	32.72	32.54	32.33	32.23	32.03	31.90
32	32.83	32.84	32.72	32.55	32.51	32.46
7	33.42	33.12	32.86	32.68	32.57	32.39
66	33.85	33.80	33.85	33.75	33.59	33.66
28	32.25	32.22	32.16	32.08	32.02	31.88
27	32.99	32.87	32.85	32.66	32.45	32.37
3	33.74	33.63	33.57	33.51	33.46	33.36
94	31.73	31.66	31.66	31.60	31.44	31.33
62	31.44	31.30	31.13	31.00	30.81	30.71
39						
82	33.04	32.98	32.94	32.83	32.71	32.57
81	31.17	31.12	31.04	31.00	30.87	30.80
4	30.24	30.21	30.20	30.22	30.22	30.19
66	33.30	33.13	32.98	32.81	32.60	32.62
44	34.54	34.42	34.45	34.40	34.34	34.26
2	33.09	32.92	32.86	32.74	32.68	32.66
56	32.53	32.44	32.35	32.26	32.17	31.96

Participant	MCBaseline	MC5min	MC10min	MC15min	MC20min	MC25min	MC30min
9	29.84	30.01	30.60	31.21	31.37	31.42	31.42
10	23.20	29.03	30.34	30.82	31.08	31.03	30.97
21	25.83	30.01	30.83	31.16	31.23	31.23	31.23
43	25.30	29.97	30.98	31.44	31.69	31.72	31.71
39	28.01	30.69	30.69	32.57	32.71	32.78	32.78
81	25.83	29.79	30.70	31.17	31.30	31.42	31.39
86	27.77	29.83	0.79	31.09	31.31	31.32	31.26
13	25.64	30.16	31.28	31.76	31.93	32.05	32.07
5	28.97	29.68	30.68	31.16	31.35	31.46	31.45
64	23.47	30.23	30.85	30.97	31.07	31.07	31.09
73	26.02	28.69	29.88	30.41	30.51	30.50	30.52
23	24.86	28.83	30.19	30.71	30.98	31.05	31.04
32	31.33	29.55	30.65	31.01	31.16	31.23	31.31
7	26.94	28.30	29.76	30.26	30.35	30.35	30.34
66	24.39	30.00	31.86	32.48	32.79	32.98	33.00
28	23.24	29.40	30.53	30.83	30.91	30.93	30.96
27	24.22	28.10	29.09	29.53	29.91	29.99	30.09
3	24.94	30.04	31.76	31.87	32.02	32.02	32.01
94	22.64	28.88	30.01	30.57	30.87	31.01	31.09
62	25.58	29.52	30.72	31.03	31.08	31.03	30.96
39							
82	27.17	28.84	29.93	30.28	30.50	30.46	30.48
81	24.29	28.52	30.05	30.66	30.90	30.92	30.92
4	27.97	29.99	30.76	30.92	30.89	30.86	30.83
66	26.61	29.42	30.66	31.26	31.35	31.34	31.33
44	26.98	30.16	31.16	31.53	31.72	31.87	31.91
2	25.68	30.99	30.95	30.87	30.82	30.79	30.73
56	25.03	30.76	31.12	31.28	31.30	31.34	31.33

Participant	MC35min	MC40min	MC45min	MC50min	MC55min	MC60min
9	31.40	31.34	31.29	31.18	31.20	31.17
10	30.90	30.90	30.97	30.96	31.01	31.01
21	31.22	31.12	31.01	30.93	30.87	30.78
43	31.66	31.61	31.66	31.54	31.55	31.55
39	32.75	32.62	32.46	32.36	32.32	32.26
81	31.35	31.28	31.26	31.26	31.28	31.23
86	31.23	31.21	31.15	31.11	31.14	31.11
13	32.08	32.06	32.01	31.90	31.82	31.82
5	31.49	31.50	31.46	31.40	31.40	31.41
64	31.10	31.08	30.94	30.97	31.00	30.89
73	30.50	30.46	30.41	30.32	30.21	30.16
23	31.02	30.99	30.91	30.85	30.79	30.73
32	31.46	31.53	31.56	31.51	31.51	31.42
7	30.32	30.21	30.11	30.10	30.07	30.00
66	33.10	31.97	32.97	32.99	32.94	33.00
28	30.95	30.91	30.91	30.91	30.89	30.82
27	30.05	30.11	30.21	30.25	30.15	30.04
3	32.07	32.04	32.03	32.02	32.01	32.03
94	31.07	31.06	31.10	31.08	31.03	30.90
62	30.88	30.77	30.71	30.68	30.57	30.48
39						
82	30.48	30.46	30.39	30.32	30.25	30.17
81	30.89	30.87	30.84	30.80	30.78	30.76
4	30.83	30.76	30.74	30.73	30.64	30.54
66	31.31	31.30	31.25	31.20	31.17	31.11
44	31.92	31.93	31.95	31.96	31.91	31.86
2	30.69	30.61	30.57	30.49	30.46	30.45
56	31.28	31.24	31.19	31.14	31.11	30.97

Participant	Gbaseline	G5min	G10min	G15min	G20min	G25min	G30min
9	27.72	29.87	30.90	31.16	31.15	31.09	31.00
10	28.15	30.55	31.97	32.30	32.50	32.72	32.53
21	24.46	31.12	32.29	32.37	32.37	32.37	32.42
43	27.37	31.97	32.50	32.85	33.03	32.86	32.85
39	25.49	30.05	31.53	31.83	31.82	31.72	31.59
81	25.20	30.89	32.33	32.58	32.66	32.72	32.71
86	28.73	29.47	30.94	31.36	31.42	31.41	31.32
13	25.87	30.05	31.21	31.46	31.43	31.46	31.64
5	25.36	31.04	32.13	32.50	32.64	32.62	32.51
64	26.71	29.38	30.66	30.96	31.19	31.14	31.19
73	25.89	30.95	32.15	32.26	32.17	31.93	31.76
23	22.48	28.39	29.47	29.32	30.05	30.11	30.13
32	24.82	31.38	33.29	33.60	33.69	33.81	33.80
7	26.58	29.34	30.39	30.65	30.67	30.66	30.65
66	24.99	31.19	32.45	32.85	32.78	32.68	32.39
28	24.40	29.60	30.77	31.17	31.20	31.21	31.17
27	21.94	27.64	28.60	29.18	29.35	29.33	29.40
3	27.05	29.82	30.77	31.41	31.58	31.70	31.75
94	22.66	31.39	32.79	32.89	32.80	32.66	32.50
62	25.82	27.96	29.22	29.60	29.91	29.98	30.01
39	23.24	28.62	29.72	30.13	30.26	30.37	30.37
82	28.44	30.95	32.03	32.62	32.94	33.09	33.16
81	24.73	30.61	31.42	31.68	31.84	31.89	31.90
4	25.57	29.51	30.63	30.82	31.03	31.06	31.15
66	28.68	30.94	32.03	32.14	32.03	31.83	31.66
44	28.57	31.55	32.67	33.20	33.48	33.52	33.62
2	26.26	30.35	31.30	31.73	31.89	31.98	32.07
56	26.57	31.22	31.73	31.93	31.83	31.76	31.71

Participant	G35min	G40min	G45min	G50min	G55min	G60min
9	30.91	30.82	30.76	30.67	30.56	30.54
10	32.48	32.42	32.29	32.21	32.04	31.92
21	32.34	32.25	32.21	32.16	32.07	31.94
43	32.62	32.62	32.63	32.55	32.41	32.32
39	31.42	31.32	31.19	31.07	30.91	30.75
81	32.66	32.51	32.47	32.42	32.39	32.34
86	31.25	31.20	31.14	31.05	31.05	31.00
13	31.37	31.28	31.21	31.15	31.05	30.96
5	32.52	32.42	32.37	32.33	32.35	32.35
64	31.22	31.25	31.19	31.16	31.30	31.32
73	31.54	31.46	31.32	31.24	31.18	31.19
23	30.08	30.05	30.03	30.03	29.98	29.92
32	33.89	33.90	33.81	33.67	33.62	33.55
7	30.60	30.58	30.43	30.43	30.24	30.09
66	32.23	32.01	31.73	31.54	31.37	31.25
28	31.17	31.13	31.03	31.07	31.05	30.93
27	29.43	29.33	29.35	29.35	29.22	29.16
3	31.65	31.70	31.68	31.83	31.83	31.81
94	32.36	32.31	32.28	32.23	32.14	32.07
62	30.06	30.02	30.00	29.98	29.96	29.91
39	30.39	30.33	30.22	30.11	30.02	30.00
82	33.21	33.30	33.44	33.49	33.53	33.56
81	31.85	31.80	31.69	31.55	31.38	31.24
4	31.25	31.29	31.47	31.36	31.50	31.38
66	31.46	31.41	31.27	31.08	31.03	31.00
44	33.71	33.71	33.73	33.69	33.58	33.55
2	32.14	32.05	31.93	31.77	31.74	31.66
56	31.55	31.48	31.50	31.40	31.33	31.26

Participant	GCBaseline	GC5min	GC10min	GC15min	GC20min	GC25min	GC30min
9	26.52	29.88	31.04	31.40	31.50	31.50	31.45
10	25.12	28.89	30.30	30.62	30.76	30.87	30.85
21	24.38	30.00	31.10	31.42	31.55	31.54	31.50
43	26.81	30.69	31.06	31.39	31.50	31.48	31.42
39	25.97	29.53	30.43	30.73	30.80	30.80	30.63
81	25.55	29.76	31.15	31.61	31.83	31.93	31.95
86	28.07	29.39	30.79	31.23	31.34	31.38	31.31
13	25.95	29.95	31.03	31.33	31.46	31.54	31.64
5	23.50	29.86	31.03	31.51	31.08	31.79	31.78
64	27.07	28.80	29.91	30.03	30.16	30.11	30.07
73	25.92	28.81	29.85	30.25	30.50	30.51	30.53
23	21.88	28.46	29.66	30.10	30.38	30.44	30.44
32	24.52	29.53	30.67	30.97	31.21	31.32	31.30
7	26.60	27.76	28.84	29.26	29.48	29.56	29.57
66	25.82	30.32	31.38	31.85	31.98	32.05	32.01
28	24.11	30.32	30.87	30.98	31.02	30.97	30.87
27	20.85	28.33	29.58	29.85	29.81	29.65	29.47
3	27.06	30.11	31.10	31.67	31.75	31.72	31.62
94	22.05	28.67	30.07	30.59	30.87	31.13	31.22
62	25.42	27.39	28.72	29.07	29.33	29.41	29.44
39	23.34	28.47	29.39	29.75	29.85	29.97	30.03
82	28.88	30.74	30.78	30.79	30.84	30.87	30.83
81	24.83	30.60	30.66	30.69	30.73	30.72	30.68
4	24.57	28.54	29.88	30.27	30.55	30.71	30.77
66	28.88	31.16	30.87	30.77	30.58	30.45	30.65
44	28.51	31.19	31.17	31.09	31.00	31.02	30.90
2	26.30	29.72	30.78	31.19	31.38	31.52	31.51
56	26.52	30.54	31.18	31.44	31.61	31.68	31.68

Participant	GC35min	GC40min	GC45min	GC50min	GC55min	GC60min
9	31.40	31.37	31.33	31.27	31.19	31.14
10	30.74	30.77	30.65	30.63	30.60	30.65
21	31.51	31.52	31.50	31.43	31.41	31.29
43	31.59	31.72	31.71	31.70	31.52	31.41
39	30.44	30.34	30.21	30.08	29.95	29.82
81	31.99	32.03	32.04	32.05	32.03	32.01
86	31.21	31.17	31.10	31.04	31.01	30.90
13	31.60	31.55	31.47	31.42	31.28	21.26
5	31.79	31.66	31.65	31.58	31.58	31.61
64	30.04	30.07	29.89	29.82	29.94	30.02
73	30.51	30.55	30.53	30.47	30.44	30.39
23	30.40	30.39	30.34	30.35	30.36	30.35
32	31.50	31.51	31.51	31.47	31.42	31.50
7	29.60	29.62	29.60	29.59	29.53	29.51
66	31.99	31.81	31.69	31.58	31.46	31.31
28	30.91	30.80	30.74	30.67	30.60	30.52
27	29.44	29.34	29.26	29.19	29.16	29.15
3	31.58	31.50	31.49	31.69	31.67	31.62
94	31.21	31.30	31.41	31.46	31.46	31.44
62	29.48	29.48	29.43	29.33	29.30	29.28
39	29.94	29.89	29.85	29.84	29.84	29.81
82	30.82	30.78	30.77	30.77	33.54	30.74
81	30.65	30.62	30.55	30.56	30.49	30.41
4	30.84	30.81	30.93	30.83	30.82	30.79
66	30.25	30.20	30.10	29.99	29.96	29.91
44	30.82	30.79	30.67	30.60	30.43	30.38
2	31.44	31.33	31.25	31.19	31.21	31.10
56	31.66	31.62	31.57	31.50	31.45	31.37

APPENDIX F: RESULTS

Frequencies

Statistics

Gender

N	Valid	28
	Missing	0

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	14	50.0	50.0	50.0
	female	14	50.0	50.0	100.0
	Total	28	100.0	100.0	

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age	28	19	32	23.00	2.596
LGirth	28	29.5	47.5	39.586	4.3194
RGirth	28	29.0	47.5	39.400	4.4280
LSkinFold	28	16	40	28.07	5.571
RSkinFold	28	13	38	27.68	5.735
Valid N (listwise)	28				

General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

condition	time	Dependent Variable
1	1	MBaseline
	2	M5min
	3	M10min
	4	M15min
	5	M20min
	6	M25min
	7	M30min
	8	M35min
	9	M40min
	10	M45min
	11	M50min
	12	M55min
	13	M60min
2	1	MCBaseline
	2	MC5min
	3	MC10min
	4	MC15min
	5	MC20min
	6	MC25min
	7	MC30min
	8	MC35min
	9	MC40min
	10	MC45min
	11	MC50min
	12	MC55min
	13	MC60min

3	1	Gbaseline
	2	G5min
	3	G10min
	4	G15min
	5	G20min
	6	G25min
	7	G30min
	8	G35min
	9	G40min
	10	G45min
	11	G50min
	12	G55min
	13	G60min
4	1	GCBaseline
	2	GC5min
	3	GC10min
	4	GC15min
	5	GC20min
	6	GC25min
	7	GC30min
	8	GC35min
	9	GC40min
	10	GC45min
	11	GC50min
	12	GC55min
	13	GC60min

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Power[a]
condition	Sphericity Assumed	630.121	3	210.040	39.252	.000	.602	117.756	1.000
	Greenhouse-Geisser	630.121	2.354	267.691	39.252	.000	.602	92.396	1.000
	Huynh-Feldt	630.121	2.603	242.055	39.252	.000	.602	102.181	1.000
	Lower-bound	630.121	1.000	630.121	39.252	.000	.602	39.252	1.000
Error (condition)	Sphericity Assumed	417.384	78	5.351					
	Greenhouse-Geisser	417.384	61.202	6.820					
	Huynh-Feldt	417.384	67.683	6.167					
	Lower-bound	417.384	26.000	16.053					
time	Sphericity Assumed	3357.096	12	279.758	192.813	.000	.881	2313.751	1.000
	Greenhouse-Geisser	3357.096	2.093	1603.770	192.813	.000	.881	403.605	1.000
	Huynh-Feldt	3357.096	2.280	1472.129	192.813	.000	.881	439.697	1.000
	Lower-bound	3357.096	1.000	3357.096	192.813	.000	.881	192.813	1.000
Error (time)	Sphericity Assumed	452.691	312	1.451					
	Greenhouse-Geisser	452.691	54.425	8.318					
	Huynh-Feldt	452.691	59.291	7.635					
	Lower-bound	452.691	26.000	17.411					
condition * time	Sphericity Assumed	101.130	36	2.809	2.944	.000	.102	105.994	1.000
	Greenhouse-Geisser	101.130	2.059	49.114	2.944	.060	.102	6.063	.558
	Huynh-Feldt	101.130	2.239	45.174	2.944	.055	.102	6.591	.584
	Lower-bound	101.130	1.000	101.130	2.944	.098	.102	2.944	.379

Error (condition* time)	Sphericity Assumed	893.050	936	.954					
	Greenhouse-Geisser	893.050	53.537	16.681					
	Huynh-Feldt	893.050	58.206	15.343					
	Lower-bound	893.050	26.000	34.348					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure:MEASURE_1

Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
31.003	.120	30.757	31.250

2. condition

Pairwise Comparisons

Measure:MEASURE_1

(I) condition	(J) condition	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	1.522*	.164	.000	1.185	1.858
	3	.944*	.216	.000	.501	1.388
	4	1.728*	.173	.000	1.371	2.084
2	1	-1.522*	.164	.000	-1.858	-1.185
	3	-.577*	.197	.007	-.982	-.173
	4	.206	.153	.189	-.108	.519
3	1	-.944*	.216	.000	-1.388	-.501
	2	.577*	.197	.007	.173	.982
	4	.783*	.133	.000	.510	1.056
4	1	-1.728*	.173	.000	-2.084	-1.371
	2	-.206	.153	.189	-.519	.108
	3	-.783*	.133	.000	-1.056	-.510

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

3. time

Estimates

Measure:MEASURE_1

time	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	25.837	.300	25.220	26.455
2	30.208	.124	29.952	30.464
3	31.001	.300	30.385	31.618
4	31.645	.123	31.394	31.897
5	31.756	.118	31.514	31.998
6	31.762	.122	31.511	32.013
7	31.733	.120	31.486	31.980
8	31.681	.121	31.433	31.929
9	31.612	.118	31.370	31.854
10	31.563	.121	31.314	31.812
11	31.498	.121	31.250	31.746
12	31.465	.127	31.204	31.725
13	31.280	.144	30.985	31.575

Pairwise Comparisons

Measure:MEASURE_1

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	95% Confidence Interval for Difference[a] Upper Bound
1	2	-4.370*	.267	.000	-4.918	-3.822
	3	-5.164*	.451	.000	-6.092	-4.236
	4	-5.808*	.278	.000	-6.380	-5.236
	5	-5.919*	.279	.000	-6.493	-5.344
	6	-5.924*	.280	.000	-6.500	-5.349
	7	-5.896*	.279	.000	-6.470	-5.322
	8	-5.844*	.280	.000	-6.419	-5.268
	9	-5.775*	.278	.000	-6.347	-5.203
	10	-5.725*	.282	.000	-6.305	-5.146
	11	-5.661*	.284	.000	-6.245	-5.076
	12	-5.627*	.278	.000	-6.198	-5.056
	13	-5.442*	.291	.000	-6.040	-4.845

2	1	4.370*	.267	.000	3.822	4.918
	3	-.794*	.278	.008	-1.366	-.222
	4	-1.438*	.053	.000	-1.547	-1.328
	5	-1.548*	.056	.000	-1.664	-1.433
	6	-1.554*	.060	.000	-1.678	-1.430
	7	-1.525*	.060	.000	-1.648	-1.403
	8	-1.474*	.064	.000	-1.606	-1.341
	9	-1.404*	.063	.000	-1.535	-1.274
	10	-1.355*	.067	.000	-1.492	-1.218
	11	-1.290*	.071	.000	-1.436	-1.145
	12	-1.257*	.078	.000	-1.416	-1.097
	13	-1.072*	.120	.000	-1.320	-.825
3	1	5.164*	.451	.000	4.236	6.092
	2	.794*	.278	.008	.222	1.366
	4	-.644*	.278	.029	-1.216	-.072
	5	-.755*	.278	.012	-1.326	-.184
	6	-.760*	.278	.011	-1.332	-.189
	7	-.732*	.276	.014	-1.300	-.163
	8	-.680*	.275	.020	-1.246	-.114
	9	-.611*	.276	.036	-1.177	-.044
	10	-.561	.275	.052	-1.127	.004
	11	-.497	.276	.083	-1.063	.070
	12	-.463	.279	.109	-1.036	.110
	13	-.279	.298	.359	-.891	.334
4	1	5.808*	.278	.000	5.236	6.380
	2	1.438*	.053	.000	1.328	1.547
	3	.644*	.278	.029	.072	1.216
	5	-.111*	.014	.000	-.140	-.081
	6	-.116*	.020	.000	-.157	-.076
	7	-.088*	.023	.001	-.135	-.040
	8	-.036	.032	.271	-.102	.030
	9	.033	.038	.391	-.045	.112
	10	.083	.042	.057	-.003	.168
	11	.147*	.046	.004	.052	.242
	12	.181*	.062	.007	.054	.308
	13	.366*	.108	.002	.143	.588

5	1	5.919*	.279	.000	5.344	6.493
	2	1.548*	.056	.000	1.433	1.664
	3	.755*	.278	.012	.184	1.326
	4	.111*	.014	.000	.081	.140
	6	-.006	.012	.642	-.031	.019
	7	.023	.016	.163	-.010	.056
	8	.075*	.025	.007	.023	.127
	9	.144*	.032	.000	.078	.210
	10	.193*	.035	.000	.121	.266
	11	.258*	.040	.000	.176	.340
	12	.292*	.056	.000	.176	.407
	13	.476*	.104	.000	.263	.690
6	1	5.924*	.280	.000	5.349	6.500
	2	1.554*	.060	.000	1.430	1.678
	3	.760*	.278	.011	.189	1.332
	4	.116*	.020	.000	.076	.157
	5	.006	.012	.642	-.019	.031
	7	.029*	.008	.001	.012	.045
	8	.080*	.017	.000	.045	.116
	9	.150*	.026	.000	.096	.203
	10	.199*	.028	.000	.140	.258
	11	.264*	.033	.000	.196	.332
	12	.297*	.050	.000	.194	.400
	13	.482*	.102	.000	.273	.691
7	1	5.896*	.279	.000	5.322	6.470
	2	1.525*	.060	.000	1.403	1.648
	3	.732*	.276	.014	.163	1.300
	4	.088*	.023	.001	.040	.135
	5	-.023	.016	.163	-.056	.010
	6	-.029*	.008	.001	-.045	-.012
	8	.052*	.012	.000	.026	.077
	9	.121*	.020	.000	.079	.163
	10	.170*	.024	.000	.122	.219
	11	.235*	.028	.000	.177	.292
	12	.269*	.046	.000	.174	.363
	13	.453*	.103	.000	.241	.666

8	1	5.844*	.280	.000	5.268	6.419
	2	1.474*	.064	.000	1.341	1.606
	3	.680*	.275	.020	.114	1.246
	4	.036	.032	.271	-.030	.102
	5	-.075*	.025	.007	-.127	-.023
	6	-.080*	.017	.000	-.116	-.045
	7	-.052*	.012	.000	-.077	-.026
	9	.069*	.014	.000	.040	.098
	10	.119*	.015	.000	.087	.150
	11	.183*	.020	.000	.142	.224
	12	.217*	.039	.000	.136	.298
	13	.401*	.099	.000	.199	.604
9	1	5.775*	.278	.000	5.203	6.347
	2	1.404*	.063	.000	1.274	1.535
	3	.611*	.276	.036	.044	1.177
	4	-.033	.038	.391	-.112	.045
	5	-.144*	.032	.000	-.210	-.078
	6	-.150*	.026	.000	-.203	-.096
	7	-.121*	.020	.000	-.163	-.079
	8	-.069*	.014	.000	-.098	-.040
	10	.049*	.013	.001	.023	.076
	11	.114*	.016	.000	.081	.147
	12	.148*	.035	.000	.076	.219
	13	.332*	.098	.002	.131	.534
10	1	5.725*	.282	.000	5.146	6.305
	2	1.355*	.067	.000	1.218	1.492
	3	.561	.275	.052	-.004	1.127
	4	-.083	.042	.057	-.168	.003
	5	-.193*	.035	.000	-.266	-.121
	6	-.199*	.028	.000	-.258	-.140
	7	-.170*	.024	.000	-.219	-.122
	8	-.119*	.015	.000	-.150	-.087
	9	-.049*	.013	.001	-.076	-.023
	11	.065*	.008	.000	.047	.082
	12	.098*	.031	.004	.035	.162
	13	.283*	.095	.006	.087	.479

11	1	5.661*	.284	.000	5.076	6.245
	2	1.290*	.071	.000	1.145	1.436
	3	.497	.276	.083	-.070	1.063
	4	-.147*	.046	.004	-.242	-.052
	5	-.258*	.040	.000	-.340	-.176
	6	-.264*	.033	.000	-.332	-.196
	7	-.235*	.028	.000	-.292	-.177
	8	-.183*	.020	.000	-.224	-.142
	9	-.114*	.016	.000	-.147	-.081
	10	-.065*	.008	.000	-.082	-.047
	12	.034	.028	.237	-.024	.091
	13	.218*	.095	.029	.024	.413
12	1	5.627*	.278	.000	5.056	6.198
	2	1.257*	.078	.000	1.097	1.416
	3	.463	.279	.109	-.110	1.036
	4	-.181*	.062	.007	-.308	-.054
	5	-.292*	.056	.000	-.407	-.176
	6	-.297*	.050	.000	-.400	-.194
	7	-.269*	.046	.000	-.363	-.174
	8	-.217*	.039	.000	-.298	-.136
	9	-.148*	.035	.000	-.219	-.076
	10	-.098*	.031	.004	-.162	-.035
	11	-.034	.028	.237	-.091	.024
	13	.185	.095	.063	-.011	.380
13	1	5.442*	.291	.000	4.845	6.040
	2	1.072*	.120	.000	.825	1.320
	3	.279	.298	.359	-.334	.891
	4	-.366*	.108	.002	-.588	-.143
	5	-.476*	.104	.000	-.690	-.263
	6	-.482*	.102	.000	-.691	-.273
	7	-.453*	.103	.000	-.666	-.241
	8	-.401*	.099	.000	-.604	-.199
	9	-.332*	.098	.002	-.534	-.131
	10	-.283*	.095	.006	-.479	-.087
	11	-.218*	.095	.029	-.413	-.024
	12	-.185	.095	.063	-.380	.011

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

4. condition * time

Measure:MEASURE_1

condition	time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	25.797	.348	25.081	26.513
	2	31.367	.136	31.087	31.648
	3	32.565	.168	32.220	32.911
	4	32.976	.180	32.606	33.345
	5	33.041	.179	32.672	33.410
	6	32.968	.180	32.597	33.339
	7	32.899	.182	32.525	33.273
	8	32.786	.180	32.415	33.156
	9	32.663	.179	32.296	33.030
	10	32.563	.180	32.193	32.932
	11	32.448	.178	32.083	32.813
	12	32.351	.178	31.985	32.716
	13	32.249	.180	31.879	32.618
2	1	25.991	.401	25.167	26.815
	2	29.607	.144	29.311	29.903
	3	29.512	1.111	27.229	31.795
	4	31.069	.123	30.815	31.322
	5	31.226	.123	30.974	31.478
	6	31.266	.129	31.000	31.531
	7	31.267	.129	31.003	31.532
	8	31.259	.133	30.987	31.532
	9	31.183	.115	30.946	31.420
	10	31.187	.130	30.921	31.454
	11	31.147	.129	30.881	31.412
	12	31.114	.131	30.844	31.384
	13	31.062	.136	30.782	31.342