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Research Article

Comparison of the Immediate Effects of Graston Technique® on Subcutaneous Hemodynamics within the Triceps Surae

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Abstract

Context: Graston Technique® (GT) is a manual therapy used by clinicians to treat soft tissue dysfunctions. It is a form of instrument assisted soft tissue mobilization (IASTM). It uses stainless steel instruments to break up adhesions in tissues. It is believed to provide increased blood flow to the treated area but evidence of the short-term effects of GT on subcutaneous hemodynamic flow is lacking, especially when comparing the GT protocol to IASTM by itself.

Objective: The purpose of this study was to determine if the GT protocol increases localized subcutaneous blood flow of the triceps surae compared to IASTM alone and a control condition.

Design: Cohort design with randomization.

Setting: Athletic training clinic.

Patients or Other Participants: 23 physically active participants (37 limbs) participated. Participant's limb(s) were randomly allocated to the GT protocol, IASTM, or control group.

Intervention: Participants had subcutaneous hemodynamics measured prior to treatment and immediately after treatment. Participants in the control group were measured at baseline and post intervention. The GT protocol group received a warm-up, instrument application, stretching, and strengthening of the triceps surae. The IASTM group received a warm-up and instrument application.

Main Outcome Measures: Subcutaneous hemodynamics including superficial and deep oxygenated/deoxygenated/total hemoglobin levels were measured.

Results: There were significantly increased levels of oxygenated hemoglobin at superficial (8.66±6.45) and deep tissues (7.90 ± 6.79) of the triceps surae only in the GT ($p = 0.002$) when compared to the control (superficial=-0.36 ± 6.44, deep=2.28 ± 3.78).

Conclusion: This study concluded that GT protocol can be effective in increasing blood flow to the treated tissues and should be considered by clinicians when looking to utilize manual therapies for increasing blood flow.

Keywords: Blood flow; GT; Hemoglobin; Manual therapy; Instrument assisted; Soft-tissue mobilization

Key Points

- Various instrument assisted soft-tissue mobilization (IASTM) techniques claim to improve blood flow following their application.
- Little to no evidence exists to the efficacy of improving blood flow with the use of IASTM.
- While a stand-alone IASTM treatment showed improvements in superficial blood flow, only the Graston Technique® demonstrated significant increases in blood flow to the triceps surae.

Introduction

Instrument Assisted Soft Tissue Mobilization (IASTM) is a manual therapy technique that utilizes instruments in order to treat soft tissue dysfunctions [1]. This technique dates back from a method used in Chinese medicine called Gua Sha, which means to "scrape or rub the surface of the body to relieve blood stagnation" [2]. The use of instruments helps to decrease clinician fatigue, increase the resonance felt through the instrument in order to detect adhesions, and produce greater force and depth of treatment [3,4]. IASTM introduces micro-trauma to an area with soft tissue restrictions and may evoke an inflammatory response in order to stimulate fibroblast recruitment and connective tissue remodeling, promote scar tissue breakdown, and fascial adhesion release [3-6]. IASTM can produce various physiologic effects that have been well researched and supported. There are multiple IASTM techniques and instruments available such as augmented soft tissue mobilization (Astym®), Fascial Abrasion Technique (FAT), sound assisted soft tissue mobilization, the Graston Technique® (GT), as well as numerous others [7].

GT uses stainless steel instruments that send vibrations to provide feedback to clinician and patient. This feedback allows the clinician to assess and treat a multitude of soft tissue dysfunctions. The GT protocol includes more than just IASTM treatment. It also incorporates a dynamic warm-up, IASTM treatment utilizing specific strokes, stretching, strengthening and cryotherapy. Because of this procedural protocol, GT claims to provide additional benefits such as improved

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perfusion of oxygen, nutrients, and blood and lymph flow to the treated tissues [8]. Past studies on the GT protocol have primarily addressed pain pressure threshold and range of motion as outcome measures. Bush et al., [9] assessed the GT protocol on the triceps surae and concluded that it may be effective in improving dorsiflexion after several treatments. Lee et al., [7] assessed the GT protocol's effect on individuals with chronic low back pain and found it to be an effective therapy for producing improvements in ROM and pain relief. A study done by Harris et al., [10] assessed the effects of GT protocol on ROM, pain pressure threshold and hemodynamics. Treatment was localized to trigger points in the upper trapezius and their results concluded that GT protocol improved blood flow and ROM but did not show any significant changes to the individual's pain pressure threshold. [10] So while plenty of literature has addressed the effects of GT protocol on changes in ROM and pain, there still remains limited evidence addressing the effect of GT protocol compared with IASTM on changes in blood flow.

There are several diagnostic tools designed to assess changes in blood flow. When wanting to address regional blood flow, the diagnostic tools include positron emission tomography (PET), single photon emission computed tomography (SPECT), xenon-enhanced computed tomography (XeCT), dynamic perfusion computed tomography (PCT), dynamic susceptibility contrast magnetic resonance imaging (DSC-MRI), and arterial spin labeling MRI (ASL-MRI) [11]. However, many of these diagnostic tools have limitations such as the depth of measurement, elevated costs, invasiveness, and varying spatial and temporal resolutions. These options can also carry a multitude of contraindications against their use.

A noninvasive and cost-effective option for assessing regional microvascular hemodynamics is near-infrared spectroscopy (NIRS). This method produces relative concentrations of deoxygenated and oxygenated hemoglobin as well as tissue oxygen saturation [12]. The NIRS is a small and wireless unit that has been shown to have good intra- and inter-subject reproducibility [13,14]. According to the American Society of Testing and Materials (ASTM) the near-infrared region of the electromagnetic spectrum is defined as the wavelength range between 780 nm and 2526 nm [15]. Light waves in this spectral range are absorbed less by superficial tissues and can penetrate approximately 6 cm into muscle tissue [16-18]. Changes in chromophore concentration such as total hemoglobin, both oxygenated and deoxygenated, can allow for the assessment of regional tissue hemodynamics via changes in local blood volume [19,20].

Frequently, published studies reference using GT, however, modify or exclude parts of the recommended protocol [4,21-24]. Bush et al., [9] assessed the full GT protocol including soft tissue warm up, instrument application, stretching, and strengthening with only instrument application for assessing changes in ROM in the triceps surae but did not report any effects to subcutaneous hemodynamic flow. Therefore, the purpose of this study was to examine the acute effects of the GT protocol on blood flow changes of the triceps surae as well as compare those results with IASTM alone and a control group. We hypothesized the GT protocol would show greater increases in blood flow when compared to both IASTM alone and no intervention.

Methods

Design

A randomized, cohort study design was used to compare the GT protocol, IASTM, and control group for assessing changes in subcutaneous hemodynamics. The participants were required to visit the athletic training clinic for one visit. Participants were randomized into one of three groups using block randomization in order to keep groups balanced with block sizes of 3 (1, 2, 3, 1, 2, 3, etc.).

Participants

Based on the power analysis calculator G*Power 3 (Heinrich-Heine-Universitat, Dusseldorf, Germany) for the ANOVA statistic with a power=0.80, α level =0.05, moderate effect size (f=0.6), and the means and standard deviations from a previous study on blood flow, the estimated total sample size for the study was 32 limbs. To assess the effectiveness of GT on subcutaneous hemodynamic flow of the triceps surae, both limbs of 43 participants were initially recruited via in-class announcements throughout the department and screened for inclusion. Twenty-four healthy participants (10 male, 14 female, ages 20.5±1.7 years, height 167.0±7.5cm, mass 62.4±17.2kg) for a total of 36 limbs met the inclusion criteria and volunteered to participate. Inclusion criteria required participants to meet the minimum ACSM guidelines [25,26] for physical activity. Exclusion criteria included any recent (within the past 6 months) lower extremity injury, any previous lower extremity surgeries, any current treatment to the triceps surae, allergy to the emollient used during treatment, burn scars or varicose veins over the calf area, kidney dysfunction, pregnancy, taking medications such as anticoagulants, steroids, hormone replacements, NSAIDs, and/or fluoroquinolone antibiotics, healing wounds, or a contagious/infectious skin disease. Qualifying participants were asked, but none had any allergies to the emollient used (Graston Technique Soft Tissue Mobilization Emollient, Graston Technique LLC, Indianapolis, IN). All participants signed an informed consent form prior to participation, and the university's institutional review board approved the research.

Measurements

Subcutaneous hemodynamic flow was measured using a wireless NIRS device (Portamon, Artinis Medical Systems, The Netherlands). Changes in chromophore concentration including superficial and deep oxygenated, deoxygenated, and total hemoglobin levels were used in the calculation of local blood flow [19,20]. Concentration changes were gathered at sample rate of 10 Hz for 2 minutes. Light absorbance at 763 nm and 845 nm allowed for the calculation of superficial and deep hemodynamics utilizing the modified Lambert-Beer Law. Light transmitting optodes were located at 30, 35, and 40 mm from the receiver allowing for light penetration between 15 and 20 mm [27]. The device was placed at the measured point halfway between the popliteal fossa and the calcaneus. The device was centered on this location and the skin was marked to ensure proper placement for the second measurement. Prior to data collection, the device was secured to the skin and covered with a light absorbing cloth to reduce any influence of ambient lighting.

Procedures

Participants met with the investigators to complete preparticipation questionnaires prior to beginning their session. Qualifying limbs were randomly allocated to 1 of 3 groups, control, IASTM, or GT, using block randomization. In instances when the participant's dominant and non-dominant legs qualified, they were both allocated to the same group. Leg dominance was self-reported by each participant as the preferred kicking leg. Following group allocation, baseline hemodynamic measurements were completed. Immediately following the completion of the treatment, post measurements were completed by placing the NIRS device back on the marked location and measuring hemodynamics for an additional 2 minutes.

Participants in the GT protocol group reported to the athletic training clinic. The author applying the GT was certified in the M1 Basic Training course and followed the guidelines when administering the intervention and had approximately 1 year of experience [8]. In order to warm up the triceps surae, participants rode a stationary bike (moderate resistance) for 5 minutes. The participant then laid prone on a treatment table with their feet hanging off, and with the edge of the table resting above the talocrural joint in a comfortable position for the patient. The GT emollient was applied with the clinician's hands to the triceps surae. A sweeping stroke was used initially with the GT5 instrument to scan the calf for adhesions for 1 minute (Figure 1). Next, the GT4 instrument was used to focus on adhesions for the remaining 4 minutes and specific adhesions were treated for no more than 60 seconds per treatment (Figure 2). The clinician also felt for any soft tissue deformities such as trigger points or crepitus. For treatment, instruments were held at a 30-45° angle while moderate pressure was maintained and sweeping, fanning, and scooping strokes were used in all directions. The total treatment time for each participant was 5 minutes. The clinician closely monitored the patient's comfort throughout the treatment session. When the treatment was over, the emollient was wiped off with a clean towel. The participant was then instructed to perform calf stretches on the slant board, holding each stretch for 30 seconds. The stretch was performed 3 times with an extended knee and 3 times with a flexed knee. Lastly, the participant performed 1 set of 15 repetitions of calf raises, flexed knee calf raises, and single-leg eccentric calf raises on a step. For the eccentric calf raise, the participant was instructed to slowly lower from the top position to the bottom position of the movement. Each participant completed one treatment and blood flow measurements were measured immediately after treatment. Cryotherapy was not included as part of the protocol because it is considered optional in the GT protocol (Tables 1 & 2).

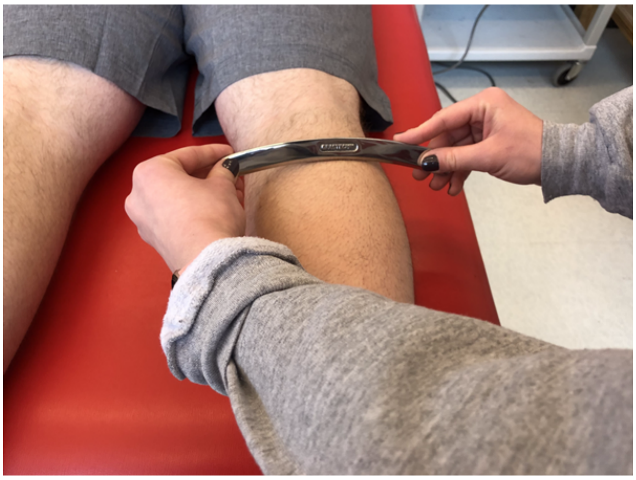

Figure 1: Graston Technique application with GT5.

Participants in the IASTM group reported to the athletic training clinic. This group did not include the stretches and exercises but followed the same instrument application. The exact same warm-up and instrument application was replicated for this group of participants. Each participant completed one treatment session and blood flow measurements were measured immediately after treatment.

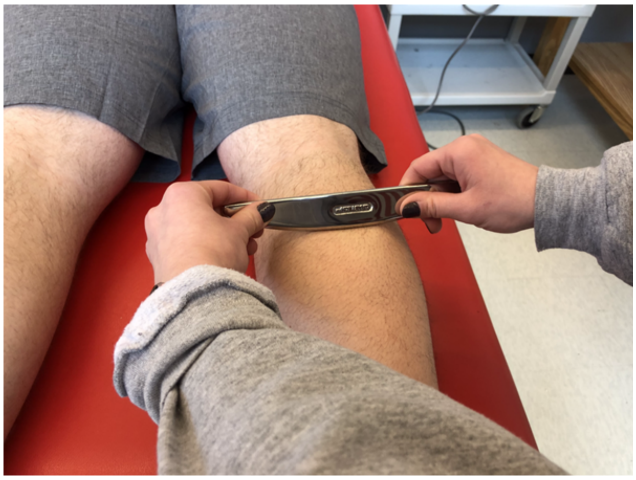

Figure 2: Graston Technique application with GT4. Figure 2: Graston Technique application with GT4.

	N (limbs)	Age (years)	Height (cm)	Weight (kg)
Control	12	19.8±1.0	166.7±9.0	64.4±14.3
IASTM	12	21.1±3.0	165.1±10.6	57.8±10.2
GT	12	20.5±1.6	169.9±6.1	64.2±22.3
All Participants	36	20.5±1.7	167.2±7.6	62.2±17.3

Table 1: Demographic data by group.

	Superficial Oxygenated	Superficial Deoxygenated	Superficial Total Hemoglobin	Deep Oxygenated	Deep Deoxygenated	Deep Total hemoglobin
GT	8.66 ± 6.45*	5.60 ± 6.98	14.25 ± 12.70	7.90 ± 6.79*	5.14 ± 6.83	13.04 ± 12.86
IASTM	6.56 ± 8.43	5.55 ± 8.46	12.11 ± 15.67	5.93 ± 7.72	4.86 ± 7.55	10.78 ± 14.21
Control	-0.36 ± 6.44	2.72 ± 4.27	2.37 ± 9.85	-0.52 ± 5.57	2.28 ± 3.78	1.76 ± 8.69

Table 2: Hemodynamics Change scores Immediate Post – Baseline.

*significant difference from the control group

Participants in the control group received no treatment. All participants, regardless of treatment group were instructed to maintain their current physical activity regimen and avoid any changes to their exercise or stretching routines.

Statistical analysis

All statistical analyses were performed using SPSS (version 25; IBM Corp, Armonk, NY). Preliminary analyses were conducted and showed no difference between groups for age (p=0.26), height (p=0.39) and mass (p=0.19). Change scores were calculated for each variable between baseline and immediately post-intervention. One-way analyses of variance were used to assess between-group differences for these variables (superficial and deep oxygenated, deoxygenated, and total hemoglobin levels). Tukey honestly significant difference post hoc testing was done to evaluated which interventions were significant among groups. The a level was set a priori at .05.

Cohen d effect sizes (ESs) for pooled standard deviations were calculated to determine the magnitude of difference among intervention groups for each outcome. Effect sizes were interpreted as small (≤ 0.2), moderate (0.3-0.7), large (≥ 0.8).

Results

The results from this study revealed significant changes between intervention groups with changes in superficial ($p = 0.01$) and deep ($p = 0.01$) oxygenated hemoglobin levels. Post-hoc tests for the superficial level revealed a significant difference between the control (-0.36±6.44) and the GT (8.66±6.45) protocol groups with a large effect size (1.38; 95% CI: 0.49 – 2.27). Post hoc tests for the deep level also revealed a significant difference between the control (2.28±3.78) and the GT (7.90±6.79) protocol groups with a large effect size (1.35; 95% CI: 0.47 – 2.24). While the results were approaching significance for the IASTM group compared with the control group, no other differences in superficial, deep, or total hemoglobin were found between groups ($p < 0.05$).

Discussion

The purpose of this study was to assess if the GT protocol increases localized subcutaneous blood flow of the triceps surae compared to IASTM and a control condition. After completing a single treatment session, the results of this study concluded the GT protocol significantly increased oxygenated hemoglobin. Blood flow did increase in the IASTM group, however, it failed to reach statistical significance. Results revealed no changes in the deoxygenated and total hemoglobin levels for deep or superficial tissues. To our knowledge, this was the first study to assess hemodynamic changes using a NIRS device on the triceps surae following IASTM and GT protocol. Additional research is necessary to further understand the significance of these effects and mechanisms behind the hemodynamic changes.

Since its early use, the GT protocol has been used as a means of restoring and improving blood flow while decreasing pain in the body [8]. Improved circulation and perfusion can increase the oxygen levels and cellular metabolism to assist in the body's healing process [28]. And increases in blood flow through manual therapy is thought to help improve microcirculation, cellular repair, granulation and angiogenesis [29]. However, there is very limited evidence assessing these claims and the potential effects that the GT protocol and IASTM may have on hemodynamics. Loghmani et al., [30] assessed microvascular morphology in rodent ligaments at the knee. After IASTM treatment, enhanced tissue perfusion and increased proportion of the arteriole-sized blood vessels was found. So while Loghmani et al., [30] assessed microvascular changes in ligaments, the current study was able to show improvements to muscular tissues such as the triceps surae. Portilio-Soto et al., [31] conducted a human study comparing the blood flow effects of the GT protocol, massage, massage control and a GT control group. The study used skin temperature as its measure of blood flow and found the GT protocol to increase blood flow as well [31]. But due to the differences in outcome measures, it is difficult to compare the significance of the effects found to the results found in the current study. Harris et al., [10] conducted a study assessing the effects of IASTM on hemodynamics of the upper trapezius using the NIRS device. The study similarly found increased oxygenated hemoglobin levels at superficial and deep tissues with the GT protocol compared to a control group and concluded that GT did increase the amount of blood flow perfusion to the treatment. Observing an increase in oxygenated hemoglobin levels may provide evidence supporting the use of the GT protocol and IASTM for promoting the healing process and reducing pain in muscular tissues.

Limitations

This study was not done without limitations. With participants in this study mostly being college-aged, it is difficult to generalize these results across a greater population. It would be particularly difficult to generalize these results to populations such as youth/adolescents, elderly individuals and elite athletes as they were not included in this study. Hemodynamics also vary between individuals and using a cross-over design may have produced more significant results in order to capture blood flow changes across the same participants.

Future research should include a more diverse population of participants. It should also consider a cross-over study design to better understand hemodynamic changes within the same individual. While this study showed the results of a single treatment, future research should consider comparing the immediate and long term effects between GT protocol and IASTM over multiple treatment sessions in order to gain a better understanding of these treatment techniques and their lasting effects.

Conclusion

The GT protocol provided significantly greater increases in hemoglobin levels of oxygenated blood flow. Based on these findings, clinicians should consider administering the full GT protocol when considering manual therapy to increase blood flow to musculature. Further research should continue to be conducted as the current literature available is still lacking assessing the effectiveness of GT on hemodynamics.

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