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The Effects of Instrument Assisted Soft Tissue Mobilization: A Systematic Review and Meta-Analysis

Sarah Johnson
sj986070@wcupa.edu

The Effects of Instrument-Assisted Soft Tissue Mobilization in the Lower Extremity: A Systematic Review and Meta-Analysis

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ABSTRACT

Objective:

To determine the overall effectiveness of instrument-assisted soft tissue mobilization (IASTM) in improving range of motion (ROM), pain, strength, and patient-reported function in the lower extremity to provide recommendations for use. We also examined the influence of IASTM on unhealthy and healthy participants, body parts treated, and products used.

Data Sources:

We searched the Academic Search Premier, Alt Healthwatch, CINAHL Complete, Cochrane Library, MEDLINE with full text, NLM PubMed, Physical Education Index, SPORTDiscus with full text, and the Web of Science databases for articles using the Boolean String advantEDGE OR astym OR graston OR iastm OR "instrument assist* soft tissue mobil*" OR "augment* soft tissue mobil*" OR "myofascial release" OR "instrument assist* massage" OR "augment* massage" OR "instrument assist* cross fiber massage".

Study Selection:

Included articles were RCT's that measured ROM, pain, strength, or patient-reported function, examined the lower extremity, and compared IASTM treatment with at least 1 other group.

Data Extraction:

Twenty-five articles met the inclusion criteria. Three independent reviewers assessed study quality using the PEDro scale. Sixteen articles were included in the meta-analysis.

Data Synthesis:

The average PEDro score for studies of uninjured participants was 7.5 (range = 4 to 9) and for studies of injured participants was 5.44 (range = 3 to 8).

Conclusions:

IASTM remains an effective modality to improve lower extremity range of motion in healthy subjects and effective in reducing pain associated with some pathologies. More evidence exists to support the effectiveness of IASTM for improving strength.

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Chapter 1: Review of Literature

Instrument-assisted soft tissue mobilization (IASTM) is a type of manual therapy used for myofascial soft tissue treatment. Clinicians have been incorporating this technique in their clinical practices to help promote recovery in localized areas and scar tissues and increase muscle strength, blood flow, skin temperature, and cell activation. In simpler terms, IASTM has been shown in previous studies to improve pain, range of motion, and patient-reported function in patients with various musculoskeletal conditions.[1] This type of myofascial release is like a massage in that it allows for pressure to be dispersed throughout the underlying tissues.[2] It does this through the use of instruments that vary in material (stainless steel, plastic, etc.) and design. There are also many techniques and application protocols that are used through companies such as Graston Technique (Indianapolis, IN),[3] ASTYM (Performance Dynamics, Muncie, IN),[4] Fascial Abrasion Technique (FIT Institute, Niagara Falls, ON, Canada),[5] and HawkGrips (Conshohocken, PA).[6] Because of the variety of techniques and products that are used for IASTM and the vast array of current literature, it can be difficult for a clinician to choose the best IASTM protocol. Also, consistent dosage parameters for IASTM such as treatment durations and lengths are unknown due to a lack of research.

PAIN

Current literature has shown that IASTM can be used to alleviate symptoms such as pain in those with various musculoskeletal conditions.[2] Pain can be measured in a few ways in a randomized controlled trial including the Numeric Pain Rating Scale (NPRS)[7,8] and the Visual Analog Scale (VAS).[9-12] These two scales are similar in that they use a 10-point numerical score to rate pain (0 = no pain; 10 = worst pain imaginable). Sanjana et al[13] and McCormack et al[7] used the NPRS to measure pain in participants with Achilles tendinopathy and non-specific low backache, respectively.

Achilles tendinopathy is most prevalent in runners as it can cause pain, swelling, and impaired function.[7] Eccentric exercise is the most recommended conservative treatment in the management of Achilles tendinopathy; however, research has recommended soft tissue mobilization to be used in conjunction with eccentric exercise. McCormack[7] used ASTYM as the intervention and performed two treatments per week (lasting 20-30 minutes) for twelve weeks. The results from this study showed that soft tissue treatment (ASTYM) plus eccentric exercise was more effective than eccentric exercise at decreasing pain in patients with Achilles tendinopathy.[7] Sanjana[13] found similar results in participants with non-specific low back pain. The M2T blade was used for a total of six sessions lasting thirty seconds each. This decrease may be due to the involvement of the Golgi tendon organs. When stimulated, they cause a myotatic stretch reflex that causes the muscle to contract and relax. When a change in tension is sustained, muscle spindle activity is inhibited, causing a decrease in the trigger point activity, resulting in a decrease in pain.[13] While there is still uncertainty of the exact mechanism, both studies found a decrease in pain.

Another study, conducted by Ragab et al,[10] ASTYM instruments were used, and the VAS scale assessed pain in those with chronic exertional anterior compartment syndrome of the lower leg.[10] Soft-tissue treatment was applied during eight sessions over four weeks (two sessions per week). The comparison group received intermittent massage (effleurage and cross fiber frictions) during their sessions. The results were similar to the previous two studies[7,13] in that ASTYM treatment was more effective than massage therapy in reducing pain.

Some limitations to these studies include small sample sizes, various treatment durations, different IASTM techniques/tools used, and inconsistent methods. There was a sample size of 30 participants in the Ragab et al[10] study and 16 participants in the McCormack et al[7] study. Even though these studies were adequately powered for the primary outcome, a larger sample size with multiple treatment sites could improve the generalizability of the results. Also, the treatment durations ranged from 30 seconds to 20-30 minutes. This makes it challenging for a clinician to

determine how long the IASTM treatment should be to achieve the intended benefits such as a reduction in pain. There is also the question as to which IASTM tool to use. ASTYM and the M2T tool were both used, and they both were successful in reducing pain.

RANGE OF MOTION

IASTM can be an essential tool in increasing range of motion.[2] Many randomized controlled trials[9-11,13-21] have focused on this particular outcome. Ankle range of motion is a popular topic because many people suffer from chronic ankle instability which can lead to a multitude of injuries. Bush et al[22] conducted an RCT to evaluate the effectiveness of IASTM for increasing dorsiflexion range of motion. A total of 23 physically active participants were included in this study and they received six treatments with a duration of five minutes per treatment. It was found that dorsiflexion greatly increased following IASTM intervention.[22] Another study using IASTM for the treatment of chronic ankle instability had results that showed an increase in all four ankle ranges of motion measurements (plantarflexion, dorsiflexion, inversion, and eversion) pre-and post-testing.[11] This study by Schaefer and Sandrey[11] included thirty-six participants and each participant received either a sham IASTM treatment or a real IASTM treatment with dynamic balance training twice a week for eight minutes for four weeks. These two studies used the same IASTM protocol with a similar dosage and got the same results. Neither, however, assessed the effects of IASTM the long-term outcomes for range of motion.

STRENGTH AND ATHLETIC PERFORMANCE

According to Seffrin and colleagues,[2] IASTM has not been consistent in increasing strength. This could be due to the variety and difficulty to measure strength. Some studies measure “athletic performance” as an outcome when using IASTM but often vary in their measurements of “athletic performance.” One study done by Jonggun Kim et al[1] examined IASTM’s ability to improve performance in young male soccer players. Specifically, they measured isokinetic power, muscle fatigue, and fitness using tests such as the side-step, sit and

reach, vertical jump, balance test, and shuttle run. The Graston technique was used as the IASTM treatment protocol, and each participant received five sessions lasting sixty minutes each per week for twelve weeks.[1] The results showed that IASTM significantly influenced isokinetic power, muscle fatigue, and fitness by facilitating soft tissue resynthesis and recovery; therefore, the authors recommend IASTM rehabilitation exercise programs to increase the physical performance in young male soccer players.[1] In comparison, Stroiney et al[12] conducted a study on IASTM on vertical and horizontal power in recreational athletes and they found that IASTM did not improve performance. They compared IASTM (using the Tècnica Gavilàn PTB technique) with self-myofascial release using a roller massager called "The Stick". The treatment was applied to each muscle group for 90 seconds (in total, the treatment was applied for 4.5 minutes). The main findings from this study were that the self-myofascial release via The Stick improved performance on the vertical jump test, whereas IASTM did not improve performance.[12] These results may be due to the way the treatment was implemented or the effect massage has on muscles on a cellular level.[12] Sullivan et al[23] conducted a study on the effects of massage on alpha motor neuron excitability and how it can affect physical performance. They found a decrease in neuromuscular inhibition and a decrease in alpha motor neuron excitability which is possibly happening at the level of the mechanoreceptors.[21] In other words, if an athlete is too relaxed after soft tissue manipulation, performance may be hindered.

PATIENT-REPORTED FUNCTION

Patient-reported function can be determined by using a questionnaire to assess how a specific condition is affecting the patient's daily life; it can also be a tool used to see how a patient's condition improves at the end of testing. Schaefer and Sandrey[11] used the Foot and Ankle Ability Measure (FAAM), activities of daily living (ADLs) and FAAM Sport questionnaires during pretesting and post-testing to detect the presence and improvement of patients with chronic ankle instability (CAI). Those with CAI, which is very common among athletes, often suffer from repeated ankle sprains. Programs with range of motion, balance, and

dynamic control training are used to improve landing and movement deficits associated with CAI.[11] However, the healing time for repeated ankle sprains is still a lengthy process. IASTM, specifically Graston in this case, has been used as a method of addressing impaired arthrokinematics related to poor tissue healing and hypomobility, adhesions, and other soft-tissue restrictions proximal to the ankle joint. Forty-five subjects with CAI received Graston IASTM for eight minutes over the entire lower leg and foot. There was a significant improvement for the pretest and post-test with FAAM ADL and FAAM Sport questionnaire results for all three treatment groups, however the changes did not exceed the minimally clinical important difference (MCID), so these changes are not clinically relevant.[11]

Similar to Schaefer and Sandrey[11], Sanjana et al[13] used the Quebec back pain disability scale as a patient-reported outcome scale in a study for subjects with hamstring tightness due to non-specific low back pain. Subjects received six treatments, lasting thirty seconds, with the M2T blade.[13] There was an overall improvement in the Quebec back pain disability scores for both the experiment and control groups. The authors hypothesized that this was most likely due to the overall improvement in the pain and hamstring flexibility that might have improved the functional ability of the individual.[13] Again, this study did not do a long-term follow-up. McCormack et al[7] examined patient-reported outcomes over a 52-week period to evaluate the long-term effects of ASTYM for subjects with Achilles tendinopathy. The 15-point Global Rating of Change scale was completed by sixteen subjects at baseline, 4, 8, 12, 26, and 52 weeks during the study. Subjects in the soft tissue treatment group achieved a successful outcome at 12 weeks compared to the exercise group and these improvements were maintained over the course of 52 weeks.[7] These long-term improvements in outcomes such as patient-reported outcomes are what healthcare providers strive to find.

The Effects of Instrument-Assisted Soft Tissue Mobilization on the Lower Extremity: A Systematic Review and Meta-Analysis

Instrument-assisted soft tissue mobilization (IASTM) is a type of manual therapy that has been incorporated into clinical practices over the last couple of decades. It is used to help promote recovery, improve scar tissues, and increase muscle strength, blood flow, skin temperature, and cell activation.[1] In previous studies, IASTM has been shown to improve pain, range of motion (ROM), and patient-reported function in patients with various musculoskeletal conditions.[2,7,11,16,24-26] The instruments used for this type of myofascial release can vary in shape, size, and material (stainless steel, plastic, etc.). The companies that develop the techniques and protocols include Graston Technique (Indianapolis, IN),[3] ASTYM (Performance Dynamics, Muncie, IN),[4] Fascial Abrasion Technique (FIT Institute, Niagara Falls, ON, Canada),[5] and HawkGrips (Conshohocken, PA).[6]

Seffrin and colleagues[2] published a systematic review of the IASTM literature in 2019.[2] They found that IASTM was effective in improving range of motion in uninjured patients, and pain and patient-reported function in injured patients. Additionally, Seffrin and colleagues[2] suggested that more high-quality research with a larger and greater variety of patient populations and tools was needed to substantiate their findings and to aid in generalizability. Since 2019, the IASTM literature has grown substantially. However, without a systematic analysis of the updated literature, it is unknown if IASTM continues to be beneficial for both healthy and unhealthy individuals.[2] We cannot assume that IASTM is still indicated for improving range of motion, pain, and patient-reported function, and that it has little to no benefits for improving

strength. Without up-to-date reviews, clinicians cannot make decisions on the most effective way to utilize IASTM when treating patients.

Given these limitations and the observed growth in the IASTM literature, the purpose of our study was to conduct a comprehensive systematic review of the effects of IASTM on pain, ROM, patient-reported function, and strength on the lower extremity. We also sought to examine the influence of IASTM on uninjured and injured participants, as well as its effectiveness on different regions of the lower extremity.

METHODS

Data Sources and Searches

We conducted a literature search using the following databases: Academic Search Premier, Alt Healthwatch, CINAHL Complete, Cochrane Library, MEDLINE with full text, NLM PubMed, Physical Education Index, SPORTDiscus with full text, and the Web of Science. The Boolean string *advantEDGE OR astym OR graston OR iastm OR "instrument assist* soft tissue mobil*" OR "augment* soft tissue mobil*" OR "myofascial release" OR "instrument assist* massage" OR "augment* massage" OR "instrument assist* cross fiber massage"* was used. We included the terms Graston Technique, ASTYM, and AdvantEDGE (the original name of ASTYM) as search terms because these are the common name brands mentioned in the articles used for the literature review. The other terms that were included in the search represent the many synonyms and variations of the term *IASTM*.

Study Selection

Articles were included if they met all the following: (1) the study is a randomized controlled trial; (2) range of motion, pain, strength, or patient-reported function is measured preintervention and postintervention; (3) the article is written in English; (4) human participants are assessed; (5) IASTM is examined as an intervention and compared with at least one other group not receiving IASTM; and (6) the lower extremity was examined. Articles were excluded if (1) the randomization methods were not clear or (2) foam rolling, or self-myofascial release was studied as the main intervention. Since the first controlled IASTM study was published in 1997, all articles published before 1997 were excluded.

The primary reviewer (S.J.J) conducted the comprehensive literature search. Once all records were imported, duplicates were removed. Titles and abstracts were then screened for potential eligibility by the primary reviewer. Once screened, the remaining articles were retrieved in full text and reassessed for the inclusion and exclusion criteria. If the primary reviewer was unsure whether a study should be included, a second author (A.M.G.S.) was consulted.

Data Extraction

Primary data extraction was performed by the lead researcher (S.J.J.) and the following characteristics were entered into a spreadsheet: author, year, pathology, or body region treated, study aim, participants, study design, experimental groups, follow-up period, participant withdrawal, outcome scales, all results, effect size reported (if provided), power analysis (if conducted a priori), and product used. A second author (A.M.G.S.) confirmed the accuracy of the extracted data. The secondary data extraction for the effect-size calculation was also performed

by the lead researcher (S.J.J.). Pre-treatment and post-treatment values for all outcomes at every time point measured in the IASTM groups were analyzed.

Quality Assessment – Physiotherapy Evidence Database (PEDro) Scale

The PEDro Scale is an objective assessment of internal validity and is the most appropriate scale for comprehensively assessing RCTs.[27] Therefore, we used it as our primary method of quality assessment (see Appendix A and B for the PEDro Scale and Criteria). Three independent reviewers (S.J.J., A.M.G.S. and 1 nonauthor) assessed the quality of the studies using the PEDro scale. After the independent scoring was completed, the primary reviewers (S.J.J., A.M.G.S.) met to determine a consensus score for each article. Any disputes in the independent assessment were settled by consensus of the one remaining nonauthor. Lastly, we searched the PEDro Website[28] to ensure that our scores were consistent with those formally assessed and confirmed in the database.

Data Synthesis and Analysis

After all data was extracted, a main table was created. Studies were organized by the uninjured or injured classification to allow for ease of readability and comparison, and then subdivided by body part or region. This took into consideration the fact that uninjured and injured tissues react differently to manual therapies.[2] The following characteristics were then transferred from the spreadsheet: author, year, pathology, or region treated, number and characterization or participants, outcomes measured, experimental groups, major results, and product used. The PEDro scores were included for reference.

Effect sizes were calculated to examine the magnitude of treatment and comparison outcomes and standardize results, permitting comparisons over time across a variety of studies

and outcome measures. The Cohen d was used to calculate the effect size for each time point reported, using the following formula:

Cohen d = Δ pretest and posttest mean / pretest (treatment or comparison group) standard deviation (SD)

Rhea categories of effect size were used to describe the calculated Cohen d effect sizes. Rhea[29] proposed 3 variations (1 for untrained, 1 for recreationally trained, and 1 for highly trained athletes) of this scale that are meant to be applied to studies that require larger effect sizes to achieve clinically meaningful results. For qualifying the effect sizes of outcomes such as ROM, use of the middle-range scale is recommended, in which effect sizes <0.35 are *trivial*, 0.35 to 0.79 are *small*, 0.80 to 1.50 are *moderate*, and >1.50 are *large*. After calculations, comparison and treatment group categorical designations were compared by time point; when the treatment-group category value exceeded the comparison-group value (eg, trivial in comparison versus moderate in treatment), it was deemed clinically meaningful.

After all effect sizes were calculated, values were plotted on a graph. Time points with moderate to large effect sizes were deemed meaningful and will allow for clinical recommendations to be made.

RESULTS

Study Selection

The initial search yielded 2,801 articles. After the lead author (S.J.J) screened for duplicates, a total of 1,613 articles remained. Titles, keywords, and abstracts were then screened for the inclusion and exclusion criteria, leaving 127 articles. Full text articles were assessed for

eligibility and were excluded with reason, leaving 44 articles which were included in the qualitative synthesis. After full-text screening, 25 articles were identified as meeting the inclusion criteria for this synthesis (lower extremity). Figure 1 provides the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram that shows the study-selection process.

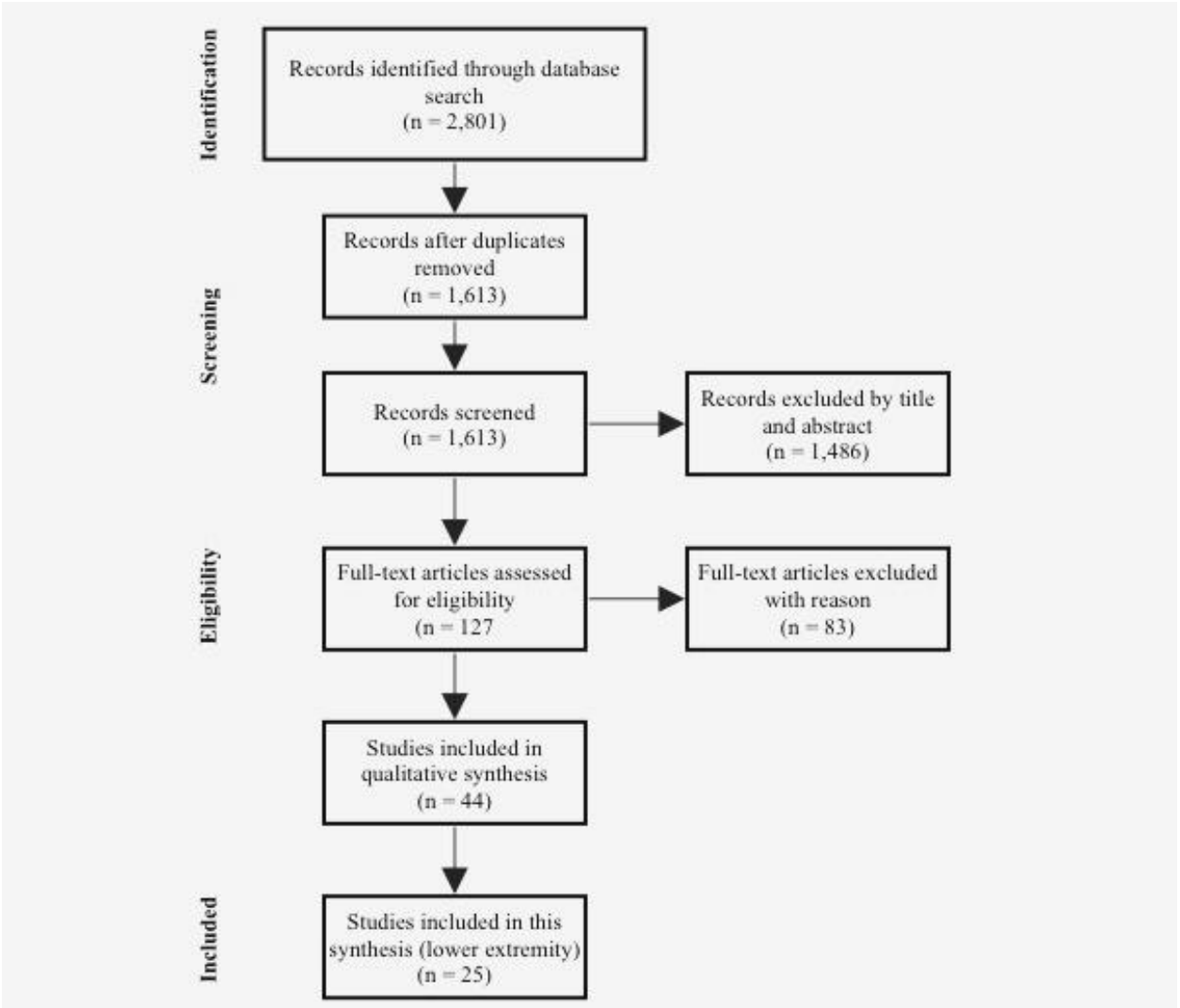


Figure 1. Screening process shown in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart.

Study Characteristics

Studies that met the inclusion criteria in the systematic search varied in their characteristics. They are presented in Table 1 with their prospective PEDro scores. Publication dates ranged from 2000 to 2021. Participants in these studies varied in age (high school to middle-age) and activity level (sedentary lifestyle to competitive athletics). As shown in Table 1, 9 IASTM instruments (ASTYM,[7,10,25] AdvantEDGE,[26] Dr. YOUSTM,[15,30] Edge Mobility Tool,[19] Ergon IASTM,[14,31] Graston Techique,[1,9,11,18,20-22,24,32,33] Fascial Abrasion Techique,[16] M2T Blade,[8,13] Tècnica Gavilàn[12]) were represented. 14 of the 25 studies found IASTM to be significant compared to the sham treatment and control groups.[1,7,8,14-16,18,22,25,26,30-32,34] The systematic search yielded 16 studies that assessed outcomes in uninjured participants[1,11,12,14-19,21,22,24,30,32-34] and 9 studies involved injured participants.[7-10,13,20,25,26,31] The 4 outcomes of interest (ROM, pain, strength, and patient-reported function) in this systematic review were assessed in part or whole depending on the study. Of the 25 included articles, 17 assessed ROM,[8-11,13-22,24,32,34] 10 assessed pain,[7-13,15,26,31] 11 assessed strength,[1,8,12,15,17,24,25,30,32-34] and 6 assessed patient-reported function.[7,11,13,20,24,26] Treatment times ranged from <5 minutes to 60 minutes; 11 studies gave <5-minute treatments,[8,9,12,13,15-17,19,21,22,30] 5 studies were in between 6–15-minute treatments,[11,14,18,24,25] 4 studies were in between 16–30-minute treatments,[7,31,33,34] 2 studies were in between 31–60-minute treatments,[1,32] and 3 studies did not report specific treatment times.[10,20,26]

Studies of Uninjured Participants

Of the 16 studies involving uninjured participants, 9 studies found that IASTM significantly improved the outcome of interest when compared to the comparison group (see Appendix C).[1,14-16,18,22,30,32,34] The majority assessed ROM and strength. Bush et al,[22] Palmer et al,[18] Park et al,[32] and Rhyu et al[34] found an increase in ankle dorsiflexion ROM. Markovic et al[16]

found an increase in lower extremity ROM compared to foam rolling. Five studies[1,15,30,32,34] found increases in strength; however, four other studies[12,17,24,33] reported no between-group improvements for strength. Kim et al[15] and Schaefer and Sandrey[11] found IASTM to decrease pain in the lower extremity, while Stroiney et al[12] did not find improvements for pain in recreational athletes. Schaefer and Sandrey[11] and Vardiman et al[24] found no changes in patient-reported function in the distal lower extremity.

Studies of Injured Participants

Of the 9 studies involving injured participants, 5 studies[7,8,25,26,31] found that IASTM significantly improved the outcome of interest, as compared to the comparison group (see Appendix D). The majority assessed pain and patient-reported function for participants with pathologies such as Achilles tendinopathy,[7] low back pain,[9] chronic exertional compartment syndrome of the lower leg,[10] patellar tendonitis,[26] groin strain,[8] and lumbar disc herniation.[31] McCormack et al[7] compared eccentric exercise only and eccentric exercise plus soft-tissue treatment (ASTYM) for subjects with insertional Achilles tendinopathy. They found that soft tissue treatment (ASTYM) plus eccentric exercise was more effective than eccentric exercise only at improving pain and patient-reported function during both short and long-term follow-up periods. Wilson et al,[26] Zaghloul et al,[8] and Zlatkov et al[31] found similar results in that IASTM improved subjective pain and function in those with patellar tendinitis, groin strain, and lumbar disc herniation.

Five of the studies[8-10,13,25] of injured participants assessed ROM. Ragab et al[10] evaluated ROM in participants with chronic exertional anterior compartment syndrome and reported that there was no significant difference between groups pre-treatment but saw an improvement in

ankle dorsiflexion post-treatment for the ASTYM group. Moon et al[9] and Sanjana et al[13] assessed ROM in participants with nonspecific low back pain. Both studies applied IASTM to the hamstrings and found an increase in hamstring flexibility.[9,13] Only two of the nine studies involving injured participants assessed strength.[8,25] Kivlan et al[25] found that ASTYM increased maximum force output immediately following treatment for participants with muscular weakness caused by a lower extremity musculoskeletal injury.

Quality Assessment

The full PEDro assessment for each article can be seen in Table 1. All included articles yielded an average PEDro score of 6.52 (range = 3 to 10). The studies of uninjured participants yielded an average PEDro score of 7.79 (range = 5 to 10), and the studies of injured participants yielded an average PEDro score of 6 (range = 3 to 10).

Blinding of the subjects, therapists, and assessors presents a considerable challenge given the nature of IASTM treatments. 13 of the 25 included studies did not blind the subjects, therapists, or assessors.[7,8,11-16,20,24,31,32,34] The three lowest-scoring works[8,26,31] failed at concealing allocation, measuring at least one key outcome, providing results of between-group statistical comparisons, and providing point measures and measures of variability for at least one key outcome.

Table 1. Quality Assessment of 25 Studies Using the Physiotherapy Evidence Database (PEDro) Scale

	PEDro Criteria											
Author (Year)	1	2	3	4	5	6	7	8	9	10	11	PEDro Score
Bush et al (2021)	Y	Y	N	Y	N	Y	N	Y	Y	Y	Y	7
Fousekis et al (2019)	Y	Y	N	Y	N	N	N	N	N	Y	Y	4
Jonggun Kim et al (2018)	Y	Y	N	Y	N	Y	N	Y	Y	Y	Y	7
Do-Hyun Kim et al (2018)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Kivlan et al (2015)	Y	Y	N	Y	Y	N	Y	N	N	Y	Y	6
Lee et al (2021)	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	7
Markovic et al (2015)	Y	Y	N	Y	N	N	N	N	Y	Y	Y	7
McCormack et al (2016)	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7
Moon et al (2017)	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	8
Osailan et al (2021)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Palmar et al (2017)	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	9
Park et al (2020)	Y	N	N	Y	N	N	N	Y	Y	Y	Y	5
Pisirici et al (2020)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Ragab et al (2020)	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	8
Rhyu et al (2018)	Y	N	N	Y	N	N	N	Y	Y	Y	Y	5
Rowlett et al (2019)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Sandrey et al (2021)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Sanjana et al (2019)	Y	N	N	Y	N	N	N	Y	Y	Y	Y	6
Schaefer and Sandrey (2012)	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	6
Stanek et al (2018)	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Stroiney et al (2018)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Vardiman et al (2015)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Wilson et al (2000)	Y	Y	N	N	N	N	Y	Y	N	N	N	3
Zaghloul et al (2020)	Y	Y	N	N	N	N	N	Y	Y	N	N	3
Zlatkov et al (2021)	Y	N	N	Y	N	N	N	N	N	Y	Y	3

Abbreviations: N, no; Y, yes.

Effect Size Comparison Over Time

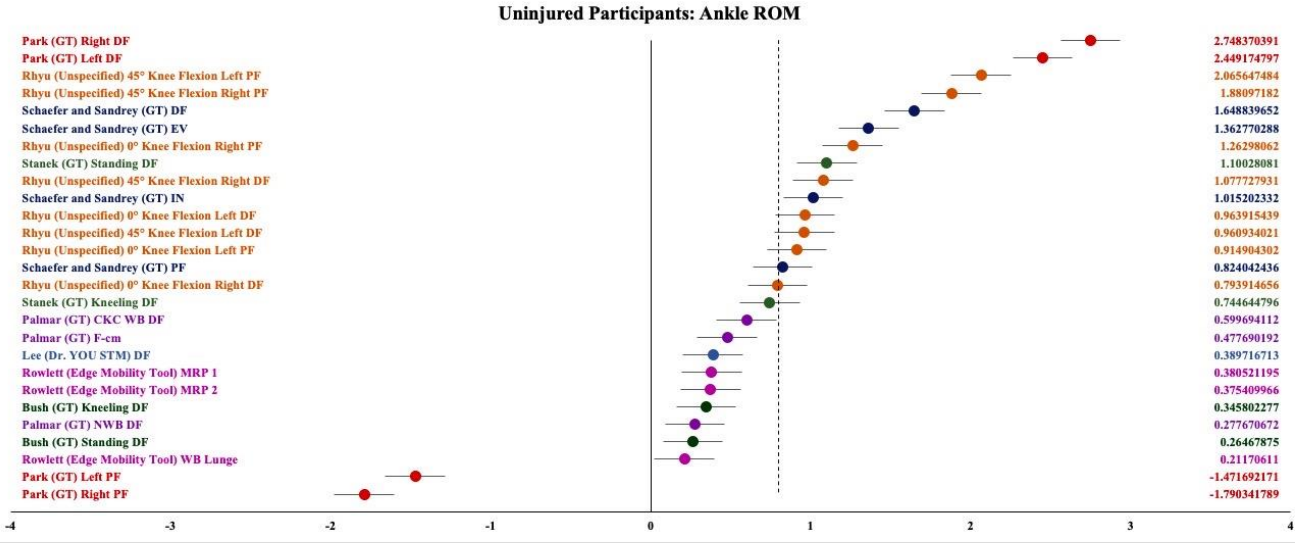
Typically, effect sizes are calculated by comparing the treatment and control groups. However, study design variations only allowed for pretest-posttest effect sizes. The formula (Cohen d = Δ pretest and posttest mean/pretest [treatment group] SD) used the pretest SD of the

treatment group. Sixteen[1,7,9-11,13,15,17-19,21,22,30-32,34] of the 25 articles in this systematic review were included in the effect-size analysis. Effect-size calculations for the treatment groups are presented in Figures 2 through 5 and Table 2. To allow easier comparisons, moderate to large effect sizes (>0.8) will be to the right of the dotted line represented on the figure.

Uninjured Participants: Ankle Range of Motion

The effect sizes of the 8 studies[11,18,19,21,22,30,32,34] on uninjured participants that assessed ankle ROM of IASTM are represented in Figure 2. Trivial to large effect sizes (0.21 to 2.75) were associated with improving ankle ROM,[11,18,19,21,22,30,32,34] with two effect sizes reflecting a decrease (-1.79 and –1.47) in ankle ROM.[32] The most common IASTM tool utilized was the Graston Technique.[11,18,21,22,32] One study failed to specify which IASTM tool was used.[34]

Figure 2. Uninjured Participants: Ankle ROM

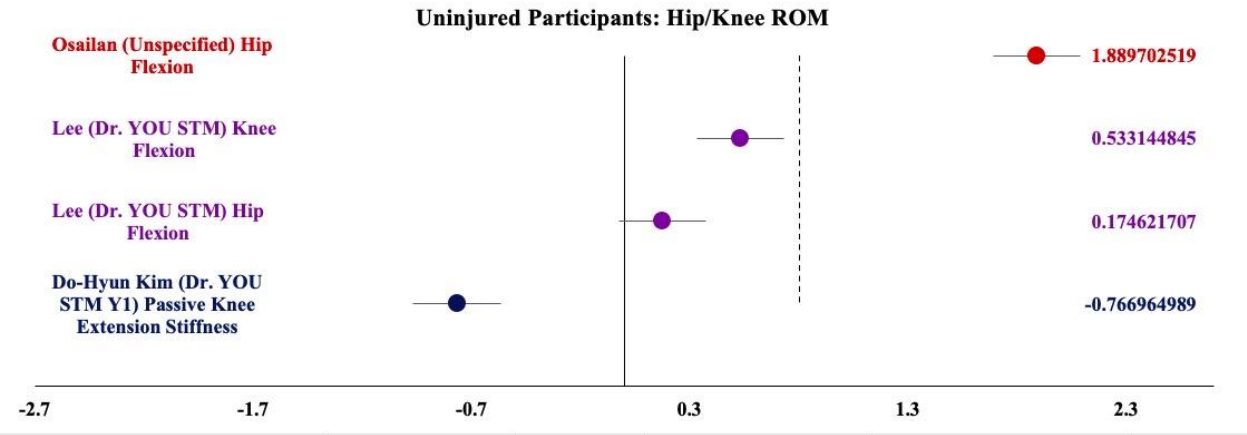


Abbreviations: GT, Graston Technique; DF, dorsiflexion; PF, plantarflexion; EV, eversion; CKC, closed-kinetic chain; WB, weight-bearing; MRP 1, modified root position 1 - knee extended; MRP 2, modified root position 2 - knee flexed; NWB, non-weight bearing

Uninjured Participants: Hip/Knee Range of Motion

Figure 3 displays the effects sizes of the 3 studies of uninjured participants that evaluated hip and knee ROM in the treatment groups.[15,17,30] Trivial to large effect sizes (0.17 to 1.89) were associated with improving hip and knee ROM.[17,30] One effect size reflected a decrease (-0.77) in knee ROM.[15] Two studies used the Dr. YOUSTM tool,[15,30] while the other study did not specify IASTM tools.[17]

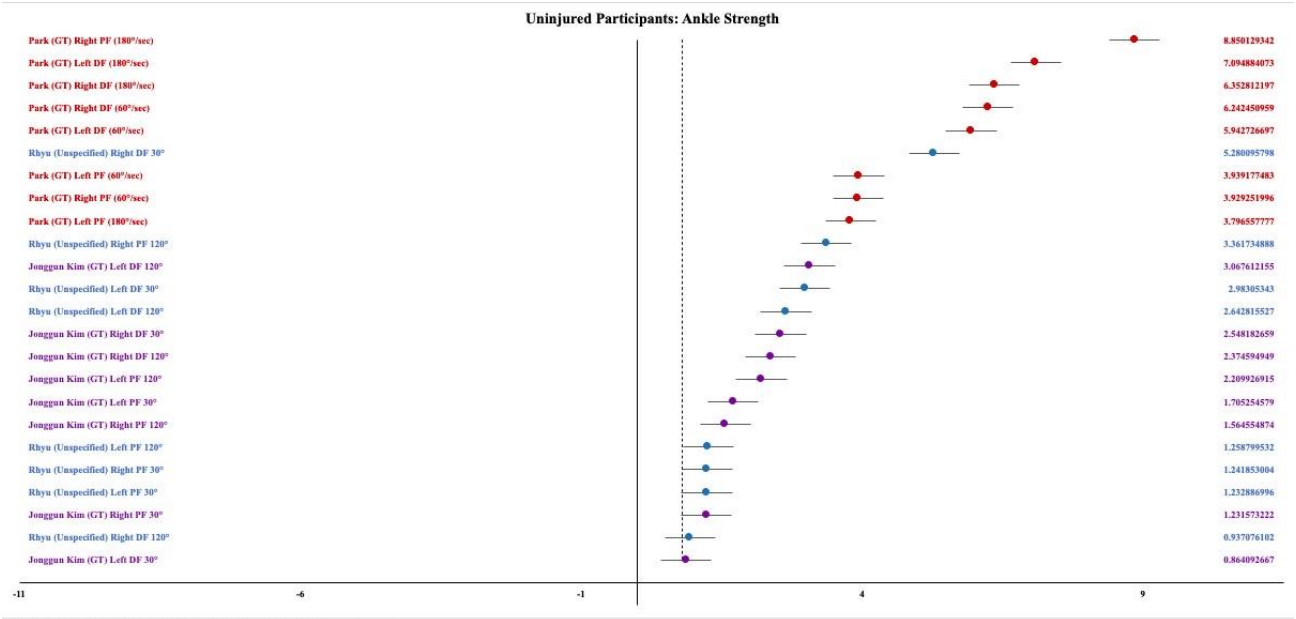
Figure 3. Uninjured Participants: Hip/Knee ROM



Uninjured Participants: Ankle Strength

The effect sizes of the 3 studies[1,32,34] on uninjured participants that assessed ankle strength of IASTM are represented in Figure 4. All effect sizes were moderate to large (0.86 to 8.85).[1,32,34] There was improvement in ankle strength for all effect sizes. Two studies used the Graston Technique,[1,32] and one study did not specify which IASTM tool was used.[34]

Figure 4. Uninjured Participants: Ankle Strength

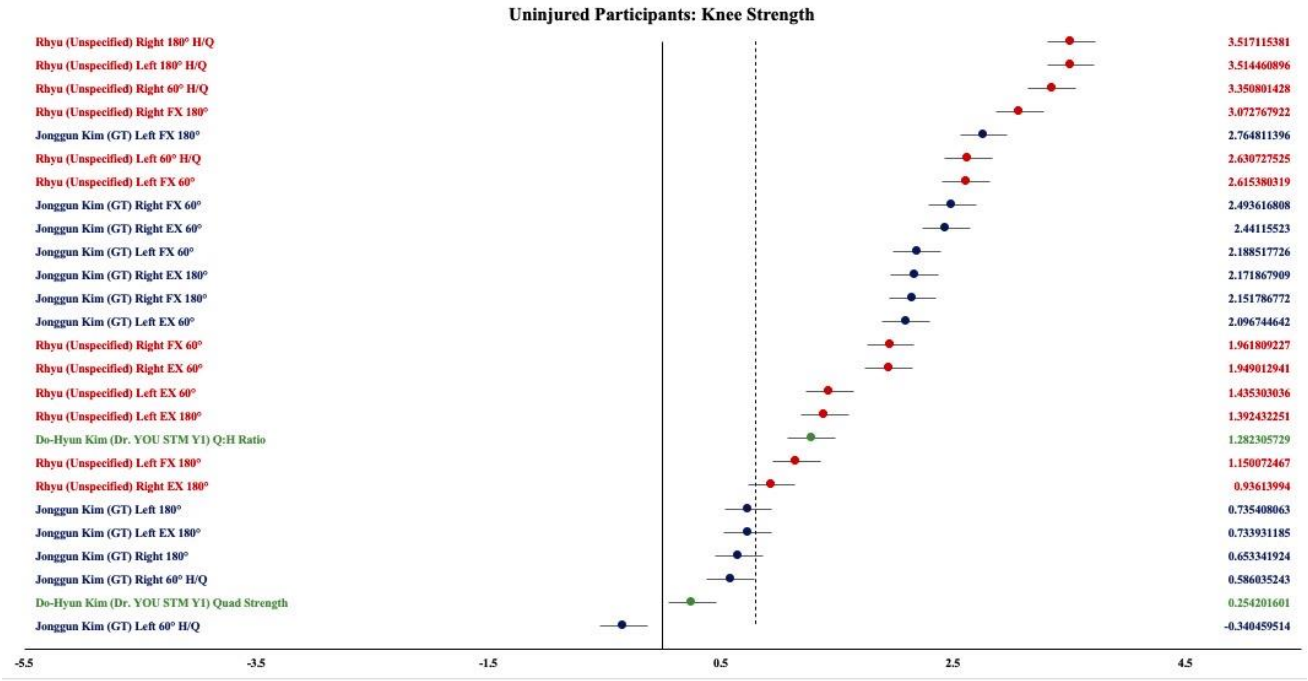


Abbreviations: GT, Graston Technique; PF, plantarflexion; DF, dorsiflexion

Uninjured Participants: Knee Strength

Figure 5 displays the effect sizes of the 3 studies of uninjured participants that evaluated knee strength in the treatment groups.[1,15,34] Trivial to large effect sizes (0.25 to 3.52) were associated with improved knee strength.[1,15,34] One effect size reflected a decrease (-0.34) in knee strength.[1] One study utilized the Graston Technique,[1] one study utilized the Dr. YOUSTM Y1 tool,[15] and one study did not specify which IASTM tool they used.[34]

Figure 5. Uninjured Participants: Knee Strength



Abbreviations: H/Q, hamstring and quadricep ratio; FX, flexion; EX, extension

Injured Participants: Pain

Table 2 displays the effect sizes of the 4 studies of injured participants that evaluated pain in the treatment groups.[7,9,10,31] Two studies used the visual analog scale in millimeters,[9,10] one study used the numeric pain rating scale,[7] and one study used the Modified Merl d'Aubigue scale.[31] The IASTM treatment groups had trivial to large improvements in pain (0.54 to 2.91),[7,9,10,31] with short-term (0-8 weeks) effect sizes ranging from trivial to large (range = 0.54 to 2.91).[7,9,10,31] Only one study[7] collected long-term (12-52 weeks) data but yielded moderate effect sizes (range = 0.93 to 1.21). Two studies used ASTYM,[7,10] one study used Graston,[9] and one study used Ergon IASTM.[31]

Table 2. Time-Elapsed Effect Size for Pain in Injured Participants

				Time-Elapsed Effect Size				Time-Elapsed Effect Size			
				Short-Term, wk		Short-Term, wk		Long-Term, wk			
Author (Product)	Condition	Treatment Time x No. of Treatments	Scale Used	0	2	4	6	8	12	26	52
McCormack et al (ASTYM)	Achilles Tendinopathy	20-30 min x 12	NPRS			0.61		0.58	0.93[b]	1.21[b]	1.19[b]
Moon (GT)	Nonspecific Low Back Pain	1 min x 1	VAS, mm	0.54							
Ragab (ASTYM)	Chronic Exertional Anterior Compartment Syndrome	Unspecified x 8	VAS			2.37[b]					
Zlatkov (Ergon IASTM)	Lumbar Disc Herniation	25 min x 6	Modified Merl d'Aubigue scale		2.91[b]						

Abbreviations: NPRS, Numeric Pain Rating Scale; GT, Graston Technique; VAS, Visual Analog Scale

[a] Effect size of <0.35 is considered trivial, 0.35-0.79 is considered small, 0.80-1.50 is considered moderate,>1.50 is considered large. A positive effect size in measurements indicates an improvement in pain.

[b] The effect size is moderate to large.

DISCUSSION

Study Selection and Characteristics

Since the IASTM systematic review in 2019 by Seffrin et al,[2] the literature has grown substantially. Seffrin et al[2] included 13 articles in their systematic review for both the upper and lower extremity, while, this systematic review included 19 new studies for the lower extremity alone. Treatment times and durations still vary considerably. The treatment times ranged from 30 seconds to 60 minutes and only one study[7] measured outcomes at timepoints over a span of 52 weeks. In comparison to Seffrin et al,[2] nine IASTM instruments were used within the 25 studies included in this systematic review including Graston Technique,[1,9,11,18,20-22,24,32,33] Ergon IASTM,[14,31] Dr. YOUSTM,[15,30] ASTYM,[7,10,25] Fascial Abrasion Technique,[16] Edge Mobility Tool,[19] M2T,[8,13] Tècnica Gavilàn,[12] and AdvantEDGE.[26] Only five tools were examined in the 2019 systematic review (ASTM AdvantEdge, ASTYM, Graston Technique, Fascial Abrasion Technique, and sound-assisted soft-tissue mobilization [SASTM]).[2] Graston continues to be the most popular tool as 10 of the 25 studies utilized it.[1,9,11,18,20-22,32,33]

Studies of Injured and Uninjured Participants

The studies included in the systematic review researched more uninjured participants (16)[1,11,12,14-19,21,22,24,30,32-34] than injured participants (9).[7-10,13,20,25,26,31] One possible reason for there being more studies on healthy/uninjured participants is that it is difficult to find multiple participants with the same pathology. Knowing this, it is only helpful for a clinician in the area of injury prevention instead of injury treatment. While healthy subjects are easier to recruit for research, the results do not necessarily transfer to a clinical aspect. Additionally, the types of pathologies examined have expanded since 2019. Chronic exertional anterior compartment syndrome of the lower leg,[10] groin strain,[8] low back pain,[9] and lumbar disc herniation[31] were not studied in the Seffrin et al[2] systematic review. The effect sizes for the unhealthy studies compared to the healthy studies were similar so IASTM can be beneficial for both groups. This can be helpful for clinicians who are looking to utilize IASTM in ways that they may not have considered previously.

Quality Assessment

The average overall PEDro score for the 25 studies included in the systematic review was 6.72. The average PEDro score for the studies involving uninjured participants (average score of 7.5) was higher compared to the Seffrin et al[2] systematic review (average score of 5.83). The average PEDro score for the studies involving injured participants (average score of 5.44) was about the same as the Seffrin et al[2] systematic review (average score of 5.86). Inadequate blinding is a consistent issue that can lead to biased results and a lower PEDro score. Blinding the therapist is impossible because of the type of treatment, blinding the assessor(s) is easier to accomplish, and blinding the participants can be done with the appropriate methods. Kivlan et

al[25] were able to blind both the participants and the assessors but failed to conceal allocation. This, with adequate follow-up, are criteria that can easily be met, however less than half of the studies included these in their methods.

Effect Size Comparison Over Time

Uninjured Participants: Range of motion. The majority of studies that assessed ROM examined the ankle, knee, and hip joints. When taking into consideration the study quality and effect size analysis, IASTM appeared to be effective in yielding short-term improvements in ankle plantarflexion,[11,34] dorsiflexion,[11,21,32,34] eversion,[11] and inversion.[11] The findings of Park et al[20] appeared to contradict these results, but this is likely due to the natural increase in ankle plantarflexion and decrease in ankle dorsiflexion associated with chronic ankle instability. Repetitive ankle sprains weaken the ligamentous and tendonous structures needed to perform dorsiflexion and plantarflexion. Schaefer and Sandrey[11] reported improvements in all four ankle ROM measurements and credited the increase in ROM post-treatment to the dynamic balance training incorporated with IASTM. For a clinician, this information is very relevant when using IASTM for those with chronic ankle instability to improve ROM.

Three studies measured hip and knee ROM.[15,17,30] Of those three studies, Osailan et al[17] was the only study to have a large effect size for hip flexion. In comparison, Lee et al[30] had a trivial effect size for hip ROM. The differing effect sizes could be due to the different methods for hip ROM measurement. Osailan et al[17] used goniometric measurements and Lee et al[30] used Image J processing software, a smartphone, and a tripod to measure ankle, knee, hip, and thoracolumbar junction kinematics while the participant performed an overhead squat for 5 seconds. Kim et al[15] used the Biodex dynamometer to determine knee extension stiffness and had

a trivial effect size which is less than 0.35. Despite having a lower effect size, they found that IASTM was superior compared to the static stretching and hold-relax groups. The conflicting results of these three studies highlight the importance of having assessments that are the same, which will allow for better comparison across studies.

Uninjured Participants: Strength. In 2019, Seffrin and colleagues[2] concluded that inconsistent findings, small effect sizes, and wide confidence intervals did not indicate improvement in strength with the use of IASTM. The current systematic review includes more studies assessing IASTM's effect on strength. Three studies measured ankle strength,[1,32,34] and all had a moderate to large effect size. All three studies also used the same isokinetic equipment to measure strength at the ankle. Kim et al[1] and Park et al[32] both used the Graston Technique as their IASTM treatment while Rhyu et al[34] did not specify which IASTM instrument they used. The consistent findings and moderate to large effect sizes in this current study, compared to the 2019 systematic review,[2] supports IASTM's ability to improve strength in the ankle.

The effect size analysis on knee strength showed similarly large effect sizes as the ankle strength analysis. Three studies measured knee strength[1,15,34] and the effect sizes ranged from trivial to large. The trivial effect size from the Kim et al[15] study could be due to the measuring of concentric strength during the Biodex isokinetic testing which would result in hamstring inhibition and a larger quadriceps activation. However, most of the effect sizes are moderate to large,[1,15,34] which is reassuring the idea that IASTM can increase strength in the knee. All three studies used isokinetic equipment for the measurement of strength, even though they did not use the same exercise protocol or IASTM tool. Rhyu and colleagues[34] had the largest effect sizes on lower limb strength in basketball players but used various training methods and rehabilitation techniques on all participants. Regardless, IASTM treatment groups were superior in all these

studies.[1,15,34] Given this new information, IASTM is effective in increasing ankle and knee strength in uninjured individuals.

Injured Participants: Pain. Four studies[7,9,10,31] measured pain in injured participants in this effect size analysis. Three different methods of assessing pain were used. These Numeric Pain Rating Scale (NPRS)[7] and Visual Analog Scale (VAS)[9,10] of pain measurement are the most used scales. Zlatkov et al[31] used the Merl d' Aubigne scale for dynamic pain. This scale is also graded, but it takes into consideration when during a movement, a patient experiences pain, and whether analgesic medication is needed. The scales are different which makes it difficult to directly compare all four of these studies.

McCormack et al[7] was the only study to measure the long-term effects of IASTM on pain. The effect sizes ranged from 0.61 to 1.21 across the 52 weeks of treatment. To determine clinical inferences, short- and long-term healing descriptors were defined and included. The fibroblastic repair phase can last from 2 days to 6 weeks. To consider factors that may impede healing (such as severity of injury and age) and to ensure the fibroblastic repair phase is completed, we set the 12-week mark as the beginning of the long-term time frame. Thus, the end of the short-term measurements and start of the long-term outcomes occurred at 3 months.[2] According to these results, IASTM can be effective in treating long-term pain for those with insertional Achilles tendinopathy. In comparison to the 2019 systematic review, new pathologies include non-specific low back pain, anterior compartment syndrome, and lumbar disc herniation. The literature has grown; however, we cannot make recommendations about IASTM's effectiveness in treating pain. This is in contrast to the 2019 systematic review because the current systematic review examined only the lower extremity.

LIMITATIONS

Comparisons are difficult to make amongst the included studies due to variations in methodology, tools used, treatment times, comparison groups and subjects included. Authors' lack of data included in these studies made it impossible to calculate traditional effect sizes, limiting this study to only compare pre- and post-effect sizes. The inclusion of a variety of pathologies and uninjured patients makes it difficult to give recommendations that are applicable to all body parts and pathologies.

DIRECTIONS FOR FUTURE RESEARCH

For future research, journals need to standardize the information that is required in the results. Studies that had to be excluded from the effect size analysis were missing important information such as treatment times and durations, pre- and post-treatment data measurements, and protocols used. Without this information, it made it more difficult to conduct an effect size analysis. When conducting the literature search, we used the same search terms as Seffrin and colleagues[2] did in 2019, to narrow down the result list to articles related to IASTM. However, the Boolean string is very long to accommodate for the many synonyms that exist for IASTM. As a result, the initial search yielded many articles that were unrelated to the topic. This makes conducting a systematic review difficult and extremely time consuming.

In 2019 Seffrin and colleagues[2] identified the need for greater consistency in the methodologies used in IASTM studies. The same recommendation can be made as a result of the current systematic review. Researchers need to examine the same protocols that have already been utilized. Current literature does not allow proper comparisons due to missing data and variations of protocols. Pathologies, acute and chronic, should be further examined to determine

if IASTM is effective for all stages of the healing process. There was a multitude of pathologies studied in the articles included in the systematic review, but there wasn't enough information provided to determine effectiveness. To help with the quality of the study, using a crossover design instead of RCT can help with the blinding of the patient and assessors.

CONCLUSIONS

The number of RCTs examining the effectiveness of IASTM for the lower extremity has increased substantially since 2019. IASTM remains an effective modality to improve ankle range of motion and ankle and knee strength in uninjured individuals. Based on the current effect-size analysis, IASTM does not appear to be effective in improving pain in injured individuals. Due to a lack of consistency across studies, we cannot determine optimal dosage parameters or make product recommendations.

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Appendix A: Physiotherapy Evidence Database (PEDro) Scale

PEDro scale

1. eligibility criteria were specified	no ☐ yes ☐ where:
2. subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	no ☐ yes ☐ where:
3. allocation was concealed	no ☐ yes ☐ where:
4. the groups were similar at baseline regarding the most important prognostic indicators	no ☐ yes ☐ where:
5. there was blinding of all subjects	no ☐ yes ☐ where:
6. there was blinding of all therapists who administered the therapy	no ☐ yes ☐ where:
7. there was blinding of all assessors who measured at least one key outcome	no ☐ yes ☐ where:
8. measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	no ☐ yes ☐ where:
9. all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"	no ☐ yes ☐ where:
10. the results of between-group statistical comparisons are reported for at least one key outcome	no ☐ yes ☐ where:
11. the study provides both point measures and measures of variability for at least one key outcome	no ☐ yes ☐ where:

The PEDro scale is based on the Delphi list developed by Verhagen and colleagues at the Department of Epidemiology, University of Maastricht (*Verhagen AP et al (1998). The Delphi list: a criteria list for quality assessment of randomised clinical trials for conducting systematic reviews developed by Delphi consensus. Journal of Clinical Epidemiology. 51(12):1235-41*). The list is based on "expert consensus" not, for the most part, on empirical data. Two additional items not on the Delphi list (PEDro scale items 8 and 10) have been included in the PEDro scale. As more empirical data comes to hand it may become possible to "weight" scale items so that the PEDro score reflects the importance of individual scale items.

The purpose of the PEDro scale is to help the users of the PEDro database rapidly identify which of the known or suspected randomised clinical trials (ie RCTs or CCTs) archived on the PEDro database are likely to be internally valid (criteria 2-9), and could have sufficient statistical information to make their results interpretable (criteria 10-11). An additional criterion (criterion 1) that relates to the external validity (or "generalisability" or "applicability" of the trial) has been retained so that the Delphi list is complete, but this criterion will not be used to calculate the PEDro score reported on the PEDro web site.

The PEDro scale should not be used as a measure of the "validity" of a study's conclusions. In particular, we caution users of the PEDro scale that studies which show significant treatment effects and which score highly on the PEDro scale do not necessarily provide evidence that the treatment is clinically useful. Additional considerations include whether the treatment effect was big enough to be clinically worthwhile, whether the positive effects of the treatment outweigh its negative effects, and the cost-effectiveness of the treatment. The scale should not be used to compare the "quality" of trials performed in different areas of therapy, primarily because it is not possible to satisfy all scale items in some areas of physiotherapy practice.

Last amended June 21st, 1999

Appendix B: Physiotherapy Evidence Database (PEDro) Criteria

Notes on administration of the PEDro scale:

All criteria	**Points are only awarded when a criterion is clearly satisfied.** If on a literal reading of the trial report it is possible that a criterion was not satisfied, a point should not be awarded for that criterion.
Criterion 1	This criterion is satisfied if the report describes the source of subjects and a list of criteria used to determine who was eligible to participate in the study.
Criterion 2	A study is considered to have used random allocation if the report states that allocation was random. The precise method of randomisation need not be specified. Procedures such as coin-tossing and dice-rolling should be considered random. Quasi-randomisation allocation procedures such as allocation by hospital record number or birth date, or alternation, do not satisfy this criterion.
Criterion 3	*Concealed allocation* means that the person who determined if a subject was eligible for inclusion in the trial was unaware, when this decision was made, of which group the subject would be allocated to. A point is awarded for this criteria, even if it is not stated that allocation was concealed, when the report states that allocation was by sealed opaque envelopes or that allocation involved contacting the holder of the allocation schedule who was "off-site".
Criterion 4	At a minimum, in studies of therapeutic interventions, the report must describe at least one measure of the severity of the condition being treated and at least one (different) key outcome measure at baseline. The rater must be satisfied that the groups' outcomes would not be expected to differ, on the basis of baseline differences in prognostic variables alone, by a clinically significant amount. This criterion is satisfied even if only baseline data of study completers are presented.
Criteria 4, 7-11	*Key outcomes* are those outcomes which provide the primary measure of the effectiveness (or lack of effectiveness) of the therapy. In most studies, more than one variable is used as an outcome measure.
Criterion 5-7	*Blinding* means the person in question (subject, therapist or assessor) did not know which group the subject had been allocated to. In addition, subjects and therapists are only considered to be "blind" if it could be expected that they would have been unable to distinguish between the treatments applied to different groups. In trials in which key outcomes are self-reported (eg, visual analogue scale, pain diary), the assessor is considered to be blind if the subject was blind.
Criterion 8	This criterion is only satisfied if the report explicitly states *both* the number of subjects initially allocated to groups *and* the number of subjects from whom key outcome measures were obtained. In trials in which outcomes are measured at several points in time, a key outcome must have been measured in more than 85% of subjects at one of those points in time.
Criterion 9	An *intention to treat* analysis means that, where subjects did not receive treatment (or the control condition) as allocated, and where measures of outcomes were available, the analysis was performed as if subjects received the treatment (or control condition) they were allocated to. This criterion is satisfied, even if there is no mention of analysis by intention to treat, if the report explicitly states that all subjects received treatment or control conditions as allocated.
Criterion 10	A *between-group* statistical comparison involves statistical comparison of one group with another. Depending on the design of the study, this may involve comparison of two or more treatments, or comparison of treatment with a control condition. The analysis may be a simple comparison of outcomes measured after the treatment was administered, or a comparison of the change in one group with the change in another (when a factorial analysis of variance has been used to analyse the data, the latter is often reported as a group × time interaction). The comparison may be in the form hypothesis testing (which provides a "p" value, describing the probability that the groups differed only by chance) or in the form of an estimate (for example, the mean or median difference, or a difference in proportions, or number needed to treat, or a relative risk or hazard ratio) and its confidence interval.
Criterion 11	A *point measure* is a measure of the size of the treatment effect. The treatment effect may be described as a difference in group outcomes, or as the outcome in (each of) all groups. *Measures of variability* include standard deviations, standard errors, confidence intervals, interquartile ranges (or other quantile ranges), and ranges. Point measures and/or measures of variability may be provided graphically (for example, SDs may be given as error bars in a Figure) as long as it is clear what is being graphed (for example, as long as it is clear whether error bars represent SDs or SEs). Where outcomes are categorical, this criterion is considered to have been met if the number of subjects in each category is given for each group.

Appendix C: Characteristics of Studies Involving Uninjured Participants

Authors	Year	Sample Size	Sample Demographics	Body Part/Pathology	Treatment Groups	IASTM Treatments x Time/Treatment	Time Points Measured	Product/Brand Used	Outcomes Assessed	Conclusions
Bush et al	2021	n=24 participants; n=37 limbs	• Age • Height • Weight	Ankle Dorsiflexion	• IASTM • GT • Control	• IASTM: 6 x 5 minutes • Graston: 6 x 5 minutes	• Baseline • 24-48 hrs post 6th treatment (3 weeks)	Graston Technique	•ROM	□ΙΑΣΤΜ □Ανκλε ΔΦ(σταναδινγ) χομ παρεδ το χοντρολ □Νο διφφερενχε βετωεεν ΓΤ ανδ IASTM
Φουσεκισετ αλ	2019	n=60	• Weight • Height • Age • Hamstring flexibility	Ημ στρινγ Φλεξιβιλιτψ	• IASTM - upper part of SBL • IASTM - lower part of SBL • Control	4 (1 per week) x 15 minutes	• Pre-intervention • Post-intervention	Ergon IASTM	•ROM	□ΙΑΣΤΜ ον υππερορλοωερΣΒΛ □ HS flexibility •No improvement for control group on SLR performance
Jonggun Kim et al	2018	n=40	• Male • Age • Weight • Height	Physical Performance	• IASTM/exercise • Control (normal training)	5 x 60 minutes (weekly; total of 12 weeks)	• Baseline (24 hours before program start) • Post intervention: 1 ωεεκ αφτερ ενδ of IASTM program	Graston Technique	•Strength	□ΙΑΣΤΜ □ατηλετιχ περφορμ ανχε χομ παρεδ το χοντρολ □ΙΑΣΤΜ □Ανκλε ανδ κνεε ισοκινετιχ ποωερχομ παρεδ το control □ΙΑΣΤΜ □μ υσχλε φατιγυε χομ παρεδ ωιτη χοντρολ
Do-Hyun Kim et al	2018	n=45	• Age • Height • Weight • Sensory integrity • AROM	Hamstring shortness	• HR • SCS • IASTM	1 x 1-2 minutes	• Pre-intervention • Post-intervention	Dr. YOU STM Y1	•Strength •ROM •Pain	□ΙΑΣΤΜ □πεακ θυαδριχεπσ στρενγτη χομ παρεδ το HP ανδ ΣΧΣ group □ΙΑΣΤΜ □Θ:Η στρενγτη βαλανχε ρατιο ωηεν χομ παρεδ το HP ανδ SCS groups □ΙΑΣΤΜ □κνεε πασσιϖε στιφφνεσσ χομ παρεδ το HP ανδ ΣΧΣ γρουπ □ΙΑΣΤΜ δεμ ονστρατεδ α ηιγηερ παιν τηρεσηολδ τηαν HP ανδ ΣΧΣ group
Lee et al	2021	n=39	• Sex • Age • Weight • Height	Λιμ ιτεδ Ανκλε ΔΦ Σψνδρομ ε	• IM • SS • HR	1 x 5 minutes	• Pre-intervention • Post-intervention	Dr. YOUSTM	•Strength •ROM	□ΙΜ γρουπ □ΤΑ:ΓΧΜ βαλανχε ρατιο χομ παρεδ το ΣΣ ανδ HP groups □ΙΜ γρουπ □Ανκλε ΔΦ ανδ Κνεε Φλεξιον ΡΟΜ χομ παρεδ το HP ανδ ΣΧΣ γρουπσ □ΙΜ γρουπ □ΤΑ μ υσχλε στρενγτη χομ παρεδ το ΣΣ ανδ HP γρουπσ
Markovic et al	2015	n=20	• Age • Weight • Height	Κνεε ανδ Ηιπ ΡΟΜ	□ΦΡ □ΦΑΤ	1 x 2 minutes	□Ιμ μ εδιατελψ after intervention • 24 hours after intervention	Φασχιαλ Αβρασιον Technique	• ROM	□ΙΑΣΤΜ □Ηιπ φλεξιον χομ παρεδ ωιτη ΦΡ □ΙΑΣΤΜ □Πρε-ποστ ηιπ ανδ κνεε flexion at both follow-up points □ΦΡ □πρε-ποστ ιμ μ εδιατε measurement only
Osailan et al	2021	n=23	• Age • Weight • Height • BMI	Hamstring Tightness	• IASTM • Manual Stretching	1 x 2 minutes	• After 5 min warm-up/Pre-intervention • Post-intervention	Υνσπεχιφιεδ	•ROM •Strength	□Νο στατιστιχαλ διφφερενχε βετωεεν Ηιπ Φλεξιον ΑΡΟΜ, ΗΜΧ τορθυε, ανδ ΗΜΧ ποωερ βετωεεν the two groups □□Ηιπ ΑΡΟΜ φορ βοτη γρουπσ

Appendix C: Continued from previous

Authors	Year	Sample Size	Sample Demographics	Body Part/Pathology	Treatment Groups	IASTM Treatments x Time/Treatment	Time Points Measured	Product/Brand Used	Outcomes Assessed	Conclusions
Palmer et al	2017	n=50	• Age • Sex • Height • Weight	Talocrural Joint ROM Athletes	• IASTM • Control	1.6 treatments per week/8 total treatments (6 weeks) x 10 minutes	• Pre-intervention • Post-intervention	Graston Technique	•ROM	
Park et al	2020	n=20	• Age • Weight • Height	Chronic Ankle Instability /	• IASTM • Control	3 treatments per week (8weeks) x 50 minutes		Graston Technique	•ROM •Strength	
Pisirici et al	2020	n=42	• Age • Height • Weight • BMI • Max jump height	Vertical Jump Performance	• IASTM • Dynamic stretch	1 x 16 minutes	• Pre-intervention • Post-intervention	Graston Technique	•Strength	• No statistical significance between groups for vertical jump performance groups
Rhyu et al	2018	n=40	• Male • Age • Weight • Height	Ability in Basketball Players	• IASTM • Control	6 treatments per week (8 weeks) x 30 min	• Pre-intervention • Post intervention		•ROM •Strength	
Rowlett et al	2019	n=60	• Age • Height • BMI	Gastrocnemius/Soleus	• IASTM • Stretching • Control	1 x 2 minutes	• Pre-intervention • Post-intervention		•ROM	control groups soleus flexibility between intervention groups in
	2012	n=45	• Age • Height	Chronic Ankle Instability	• Dynamic-Balance- IASTM IASTM treatment IASTM)	Two treatments per week (2 weeks) x 8 minutes	• Pre-intervention after last session • Post-intervention within the week after final treatment)	Graston Technique	•ROM •Pain	outcome between groups
Stanek et al	2018	n=44; 53 limbs	• Age • Height • Weight		• IASTM • CMR • Control	1 x 5 minutes	• Pre-intervention • Post-intervention	Graston Technique	•ROM	intervention
Strouiney et al	2018	n=49	• Age • Height	Power in Recreational Athletes	• IASTM • SMR	minutes	• Pre-intervention • Post-intervention	Técnica Gavilán	•Pain •Strength	to IASTM between groups for pain between groups for sprint performance
	2015	n=11	• Age • Male • Height • Weight		• IASTM • Control	1 x 7-8 minutes	• Pre-intervention • Post-intervention • 24 hours • 48 hours • 72 hours	Graston Technique	•ROM •Strength •Pain	strength

Appendix D: Characteristics of Studies Involving Injured Participants

Authors	Year	Sample Size	Sample Demographics	Body Part/Pathology	Treatment Groups	IASTM Treatments x Time/Treatment	Time Points Measured	Product/Brand Used	Outcomes Assessed	Conclusions
Kivlan	2015	n=45	•Age •Height •Weight •Gender •LE-dominance •Musculoskeletal diagnosis	Muscle Performance on LE	•IASTM •Placebo •Control	1 x ~12 min	•Pre-intervention •Post-intervention	ASTYM	Strength	• IASTM ↑ maximum force output immediately following treatment • Placebo and control groups were found not to be statistically different
McCormack	2016	n=16	•Age •Sex •Duration of symptoms •Height •Weight •Smoking status •Presence of Diabetes Mellitus •Heel lift usage	Achilles Tendinopathy	•IASTM & Eccentric Exercise •Eccentric Exercise	2x per week over 12 weeks x 20-30 minutes	•Baseline •4 weeks •8 weeks •12 weeks •26 weeks •52 weeks	ASTYM	•Pain •PRF	• IASTM plus eccentric exercise is more effective than eccentric exercise alone
Moon	2017	n=24	•Gender •Age •Height •Weight	Nonspecific Low Back Pain	•IASTM •SS	1 x 60 seconds	•Pre-intervention •Post-intervention	Graston Technique	•ROM •Pain	•IASTM ↑ hamstring extensibility compared to SS group •No statistical difference in pain
Ragab	2020	n=30	•Age •Weight •Height •BMI •Systolic BP •Diastolic BP	Chronic Exertional Anterior Compartment Syndrome of lower leg	•IASTM •Intermittent massage treatment	8 sessions over 4 weeks	•Pre-intervention •Post-intervention	ASTYM	•Pain •ROM	•IASTM ↓ pain compared to massage therapy •IASTM ↑ ankle DF compared to massage therapy
Sandrey	2021	n=20	•Age •Gender •Past medical history •Current activity level	Knee Joint ROM, Rectus Femoris and Biceps Femoris Fascial Displacement, and Patient Satisfaction	•IASTM •FR	6 treatment sessions over 3 weeks	•Pre-intervention •Post-intervention	Graston Technique	•ROM •PRF	•IASTM was more effective than the FR group in ↑ rectus femoris fascial displacement •FR was more effective than IASTM in ↑ knee extension ROM
Sanjana	2019	n=48	•Age •Duration of symptoms •Gender	Hamstring Tightness in Non-Specific Low Backache	•TENS, Mulligan's BLR and conventional exercise •TENS, IASTM for Hamstrings and conventional exercises	6 sessions x 30 seconds	•Pre-intervention •Post-intervention	M2T	•ROM •Pain •PRF	•Both groups showed significant improvement for NPRS for pain and PRF •Both groups showed ↑ in hamstring flexibility •No improvement lumbar lordosis in either group
Wilson	2000	n=20	•Age •Gender	Patellar Tendonitis	•Traditional treatment •IASTM	2x per week for 4 weeks	•Week 0 •Week 6 •Week 12	AdvantEDGE	•Pain •PRF	•IASTM improved subjective pain and function compared to the traditional treatment group
Zaghloul	2020	n=46	…	Groin Strain	•IASTM •Ultrasound therapy •Deep friction massage •Control	15 sessions over 5 weeks x 3-5 minutes	•Baseline •1st week •3rd week •End of intervention	M2T Blade	•Pain •ROM •Strength	•IASTM and US showed a significant improvement on pain, recovery, and proper healing •US was effective in reducing pain intensity and accelerating healing but IASTM was more effective in gaining recovery •DFM only has a tissue healing effect
Zlatkov	2021	n=36	•Height •Weight •BMI	Lumbar Disc Herniation	•IASTM •Control	3x a week for 2 weeks x 25 minutes	•Pre-intervention •Post-intervention	ERGON IASTM	•Pain	•IASTM improved pain symptoms and functional capabilities as compared to the control group