



Article

Effects of Instrument Assisted Soft-Tissue Mobilization on Dynamic Balance in Those with Chronic Ankle Instability

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Abstract: Our objective was to examine the effectiveness of IASTM application to the FL on dynamic balance in individuals with CAI. Fifteen individuals (seven females, eight males, age = 26.07 ± 9.18 years, mass = 87.33 ± 24.07 kg, height = 178.83 ± 12.83 cm) with CAI, as determined by the Ankle Instability Instrument (AII) volunteered to participate. Participants completed two counterbalanced sessions (experimental and control), and we recorded measurements at two time points (pre- and post-). The application of IASTM to the FL muscle was carried out using Técnica Gavilán[®] instruments for 90 s during the intervention, and participants sat for 2 min during the control session. Dynamic balance was assessed using the Y-balance test (YBT). The interaction between session and time for anterior reach was significant ($F_{1,14} = 5.26$, $p = 0.04$, $\eta^2 = 0.27$). Post-hoc tests revealed farther reach distances at post-test (71.02 ± 9.45 cm) compared to pre-test (66.57 ± 10.87 cm) when IASTM was applied ($p = 0.02$, Mean Difference = 4.45 cm, $CI_{95} = 0.71$ – 8.19 cm, Cohen's $d = 0.44$). The interaction between session and time was not significant for posteromedial ($F_{1,14} = 0.25$, $p = 0.62$, $\eta^2 = 0.02$, $1 - \beta = 0.08$) or posterolateral reaches ($F_{1,14} = 1.17$, $p = 0.30$, $\eta^2 = 0.08$, $1 - \beta = 0.17$). The application of IASTM to the FL improved anterior reach of the YBT, but not posterolateral or posteromedial reaches in individuals with CAI. However, the 4.45 cm increase in anterior reach could have clinical implications for improved function.

Keywords: injury risk reduction; therapeutic exercise; therapeutic devices; manual techniques



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1. Introduction

Ankle sprains, by definition, are tears to the ligaments connecting structures of the ankle joint [1]. Ligamentous integrity is often disrupted, causing them to lose their original structure and function after ankle injury. If a person injures his or her ankle repeatedly, it can lead to chronic instability of the joint, or chronic ankle instability (CAI), due to the ligaments receiving repeated trauma [2]. Individuals with CAI can suffer from a variety of functional deficits, such as decreased strength [3], altered proprioception [4], impaired balance [5], hypomobility, feelings of instability, and recurrent ankle sprains [6,7]. The functional deficits may be due to adhesions in the muscles and ligaments around the ankle, as well as damage to sensory receptors within the joint causing delays in muscle activation and sensory feedback.

In an attempt to prevent or minimize instability and its associated symptoms, rehabilitation is often suggested for those who suffer ankle injuries. Ankle rehabilitation often consists of restoring range of motion (ROM), strength, and dynamic balance to the ankle joint and surrounding musculature. In order to achieve the goals of rehabilitation, different modalities and manual therapy techniques may be used [8]. Patients may have strength and ROM deficits, specifically with eversion after ankle injury [3]. A primary focus of ankle sprain rehabilitation is strengthening and restoring the dynamic balance of the fibularis longus (FL) muscle, due to its strength as an ankle evtor, along with its tendency to have reduced neural excitability in individuals with CAI [9].

Additionally, when the ligaments in the ankle are sprained, damage to mechanoreceptors can cause dynamic balance deficits [2]. Clinicians can attempt to compensate for dynamic balance deficits by stimulating mechanoreceptors in muscles that cross the ankle joint, such as the FL. There are an assortment of modalities and manual therapy techniques that can be used in conjunction with ankle rehabilitation to assist with the improvement of dynamic balance in the ankle joint. One of these techniques is instrument-assisted soft tissue mobilization (IASTM), which is typically used to address impairments related to soft tissue structures. The application of IASTM is used to treat fascial adhesions and, like massage, is able to stimulate sensory receptors [8,10]. Massage, a similar modality to IASTM, has been shown to enhance dynamic balance in individuals with CAI when applied to the plantar aspect of the foot [8]. The use of IASTM on the lower leg has been shown to improve ROM and dynamic balance of chronically unstable ankles when used in conjunction with balance training [11]. However, the immediate effects of using IASTM by itself as a treatment for improving dynamic balance in individuals with CAI remains unknown. The purpose of our study was to examine the effectiveness of IASTM acutely on dynamic balance in individuals with CAI, when applied to the FL. Our specific aim was to determine if acute IASTM application to the FL would improve Y-balance test (YBT) reach distances in those with CAI.

2. Methods

We performed a 2×2 repeated measures crossover design to collect the data for this study. The independent variables for our study were session (intervention and control) and time (pre- and post-test). We assessed dynamic balance using the 3 reach measurements of the YBT.

2.1. Participants

Based on a power analysis ($1 - \beta = 0.80$, α level = 0.05) of a previous study [7], the sample size for this study exceeded estimations for adequate power. A total of 15 individuals (7 females, 8 males, age = 26.07 ± 9.18 years, mass = 87.33 ± 24.07 kg, height = 178.83 ± 12.83 cm) met the inclusion criteria and volunteered to participate. Volunteers enrolled in the study if they answered “yes” to the first question regarding history of ankle sprain and 4 or more of the additional dichotomous questions on the ankle instability instrument [AII] [12]. Questions on the AII asked about visits to a physician for an ankle sprain, ability to bear weight after an ankle sprain, experiences of the ankle “giving way”, and 5 questions related to the ankle feeling unstable during various activities [12]. Volunteers were excluded from the study if they had sustained any lower leg, hip, or low back injury, or if they had experienced a concussion in the last 6 months. Other exclusion criteria included knee instability, vestibulocochlear impairments, osteoarthritis, rheumatoid arthritis, total replacement of a lower extremity joint, or answering “yes” to one or more questions on the physical activity readiness questionnaire (PAR-Q) [13,14]. All participants were provided with a written informed consent form and, the study was approved by the Institutional Review Board of the host university (approval number LHS1819005).

2.2. Instruments

The AII is a survey consisting of 9 dichotomous (yes/no) questions and is used to assess chronic ankle instability with a strong reported reliability (Cronbach alpha coefficient = 0.92 for initial ankle sprain severity, 0.87 for ankle instability history, 0.81 for instability during activities of daily living, and 0.89 for the instrument overall) [11,15]. If participants answered “yes” to the first question regarding a history of ankle sprain, and 4 or more of the remaining questions, they were categorized as having CAI [12] and, thus, were deemed eligible to participate in the study. Mechanical ankle instability was not considered in the current study. Eligible participants performed the YBT (intrarater reliability = 0.91) to assess dynamic balance of the limb with CAI with one investigator supervising all testing and recording all measurements (Figure 1) [15,16].



Figure 1. YBT (A) Anterior reach, (B) Posteromedial reach, (C) Posterolateral Reach.

2.3. Procedures

All participants completed 2 counterbalanced sessions. One session consisted of the application of IASTM to the FL on the limb with CAI (experimental session), while the other consisted of participants sitting for 2 min (control session), with the same lower limb being used for all sessions and testing. Each session was separated by approximately 7 days (mean = 8.06 ± 2.60) [17]. Participants were asked to read and sign an informed consent agreement, complete the AII for the ankle they previously sprained and felt was unstable, and complete a PAR-Q at the beginning of their first session. The lower limb that corresponded to the ankle that participants used for the AII was used consistently throughout the study for leg length measurements, undergoing the intervention and control sessions, and all YBT testing. All participants then had their age, height, mass, and true, or anatomical, leg length recorded [18]. Height was measured using a Seca 213 Mobile Stadiometer with Integrated Level (Seca, Chino, CA, USA), mass was measured using a WB-800S plus Digital Scale (Tanita, Arlington Heights, IL, USA), and leg length was measured from the anterior superior iliac spine (ASIS) to the medial malleolus on the limb with CAI, using a standard anthropometric use tape measure. We used the participants' leg length measurements to normalize YBT reach distances using the formula (reach distance [cm]/leg length [cm]) * 100 [19].

The participants completed a 5 min self-selected speed warm-up on a Monark Ergonomic 828E stationary bike (Monark, Vansboro, Sweden) [15]. Afterwards, participants performed 4 barefoot practice trials on the FMS Professional YBT kit to minimize the learning effect, and then completed 3 barefoot pre-test trials by reaching in each direction 3 consecutive times, before moving on to the next reach direction [19]. Participants started with the anterior reach direction, then moved to the posteromedial direction before finishing with the posterolateral direction.

Next, the experimental session participants received IASTM for 90 s over the FL [20]. Prior to conducting IASTM, cocoa butter moisturizing lotion (Palmer's, Englewood Cliffs, NJ, USA) was applied to the treatment area with the edge of the instrument to decrease friction and prevent skin irritation during treatment [20]. The application of IASTM to the limb with CAI was carried out using a Garra instrument (Técnica Gavilán, Riverside, CA, USA; Figure 2), to the lateral lower leg between the fibular head and lateral malleolus, with the focus being on the FL (Figure 3). Instrument-assisted soft tissue mobilization was performed with sweeping strokes for 90 s at 30 beats per minute, with the stroke direction changing with every beat; the beat was kept using the phone application Metronome (EUMLab, Hangzhou, China) [11,20,21]. All intervention treatments were conducted by one clinician trained in performing IASTM. During the control session, participants sat for 2 min. After receiving IASTM or sitting, the participants completed 3 barefoot post-test trials of each direction of the YBT, exactly the same as the pre-test measurements [22].



Figure 2. Técnica Gavilán® Garra Instrument.



Figure 3. Application of IASTM to the FL of the Limb With CAI.

2.4. Statistical Analysis

The independent variables were session (experimental, control) and time (pre-test, post-test), and the dependent variable was the YBT distance for each of the 3 directions. Using SPSS (version 25; IBM Corp, Armonk, NY, USA), we calculated 2×2 repeated

measures ANOVAs for each of the 3 reach directions with an alpha value of $p < 0.05$ a priori so as to determine the effectiveness of IASTM on YBT reach distances in individuals with CAI. We followed up significant main effects with post-hoc tests with Bonferroni corrections, and calculated confidence intervals and Cohen's d for any pairwise significant differences.

3. Results

Means and standard deviations for all variables are reported in Table 1. The interaction between session and time for anterior reach was significant ($F_{1,14} = 5.26$, $p = 0.04$, $\eta^2 = 0.27$). Post-hoc tests revealed farther reach distances at post-test (71.02 ± 9.45 cm) compared to pre-test (66.57 ± 10.87 cm) when IASTM was applied ($p = 0.02$, Mean Difference = 4.45 cm, $CI_{95} = 0.71$ – 8.19 cm, Cohen's $d = 0.44$). However, the interaction between session and time was not significant for posteromedial reach ($F_{1,14} = 0.25$, $p = 0.62$, $\eta^2 = 0.02$, $1 - \beta = 0.08$) or posterolateral reach ($F_{1,14} = 1.17$, $p = 0.30$, $\eta^2 = 0.08$, $1 - \beta = 0.17$) directions (Figure 4).

Table 1. YBT Reach Distances (Mean \pm SD cm) * Significantly different than IASTM pre-test; $p = 0.02$.

Group	N	Anterior		Posteromedial		Posterolateral	
		Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
Control	15	70.05 \pm 10.87	68.85 \pm 12.15	108.19 \pm 10.06	107.77 \pm 10.36	102.85 \pm 9.51	103.40 \pm 12.35
IASTM	15	66.57 \pm 10.87	71.02 \pm 9.45 *	101.78 \pm 9.96	109.38 \pm 10.40	99.01 \pm 13.29	101.96 \pm 11.94

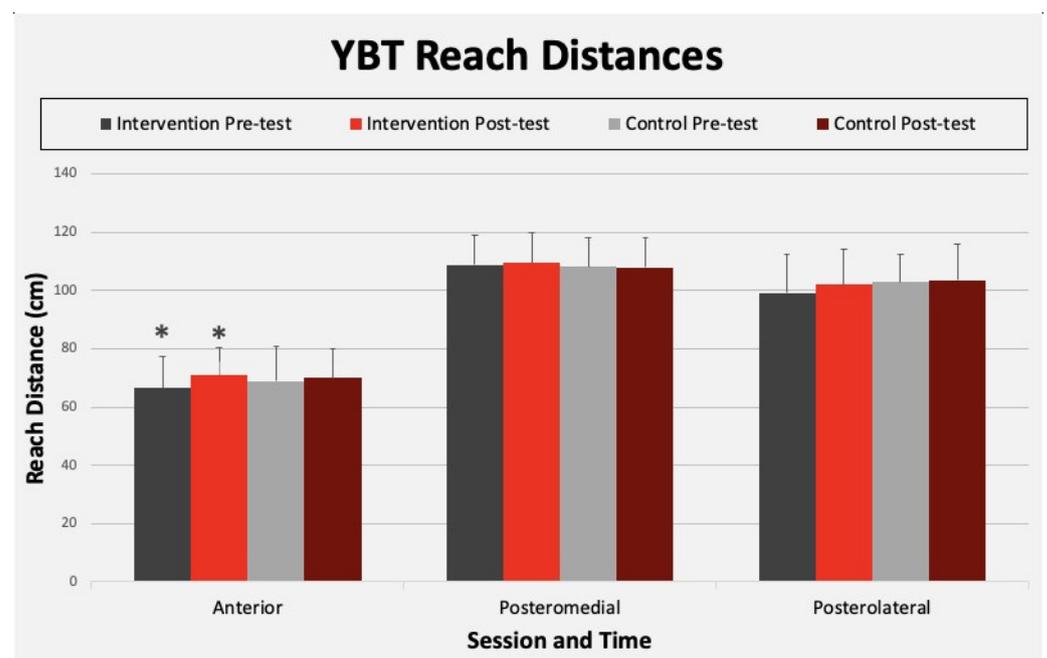


Figure 4. Differences in YBT reach distances across session and time. * Significantly greater reach at post-test compared to pre-test ($p < 0.05$).

4. Discussion

The purpose of our study was to determine the effectiveness of the acute application of IASTM on dynamic balance in individuals with CAI. The main finding of our study was that there was an increase in YBT anterior reach distances pre- to post-test when IASTM was applied to the FL for 90 s. We believe our findings are important as those with CAI have been found to have dynamic balance deficits and ankle muscle activity reductions during unilateral jump-landing tasks [23]. A study conducted by Ahn et al. [24] compared lower leg muscle activation in individuals with stable and functionally unstable ankles while they performed the Star Excursion Balance Test (SEBT). Ahn et al. found a significant

difference in FL muscle activation between the two groups, with the unstable group having less activation when performing the anterior reach of the SEBT, but not with posteromedial reach and posterolateral reach [24]. Results of meta-analyses have also found reduced FL excitability in patients with CAI, which may impair balance [25,26]. Furthermore, delayed activation of the FL during some functional tasks and inversion perturbations have also been illustrated in those with CAI, which stresses balance in challenging tasks [27]. Since the deficit in FL activation has been found to be the most significant with anterior reach, we believe that this could be an explanation as to why anterior reach improvements were significant in our study after IASTM application, but not for the other two directions.

One proposed use of the YBT is to utilize it as an injury prevention screening tool. It has been suggested that neuromuscular control (NMC) is an injury risk factor that can be modified and improved, and that YBT is a reliable method of assessing dynamic balance [16,28]. Indeed, YBT has been found to be a diagnostic screening tool for risk of non-contact injuries (sensitivity, 59%; specificity, 72%) [22]. If an athlete's anterior reach distance asymmetry is greater than 4 cm, it can indicate that the athlete is at an increased risk of non-contact injury with an odds ratio of 2.20 [22]. The results of our study show that after IASTM was applied to the FL, anterior reach distance increased 4.45 cm pre- to post-test, indicating that the utilization of IASTM could reduce asymmetries and potentially lower the risk of non-contact injury if a discrepancy is identified in the ankle with CAI.

4.1. Manual Techniques

Joint mobilizations, plantar massage, and calf massage are alternative modalities or manual therapies that produce similar outcomes to IASTM that have been performed on individuals with CAI with the intention of improving NMC [8,22,29]. Comparable to the use of IASTM in our study, the effects of grade III anterior-to-posterior talar joint mobilizations on NMC have also been assessed in individuals with CAI [29]. In a study conducted by Harkey et al. [29], it was found that talar joint mobilizations improved ROM in a similar way to IASTM [29]. However, they did not improve anterior reach, posteromedial reach, or posterolateral reach SEBT performance. The findings contrast with our results which indicated an improvement in anterior reach distance. Harkey et al. [29] discussed that anterior-to-posterior talar joint mobilizations acutely improve neural excitability of the soleus, which differs from the muscle tested in our study [29]. The contrast in the findings of our studies could be due to the different muscles affected by the interventions and how they affect ankle motion and stability.

Massage is a manual therapy that could be considered the most similar to IASTM in physiological effects. One of these similarities includes the stimulation of sensory receptors [8,10,22]. Two specific locations that massage has been applied to, in comparison to our application of IASTM to the FL, are the plantar aspect of the foot and calf [22]. Plantar massage treatment is proposed to reduce the higher light-touch threshold in the plantar aspect of the foot that is associated with CAI, and this sensory deficit is associated with postural control impairments [22]. A study performed by Wikstrom et al. [22] examined the effectiveness of plantar massage on NMC using three different mediums (manual, ball, and brush) for the massages. Static NMC was assessed with center of pressure software with a force plate, and had significant improvements with all massage mediums. Dynamic NMC was assessed with SEBT across these three types of plantar massages, and no significant improvements in SEBT measurements were found [22]. Additionally, it was found that the manual plantar massage was the most effective of the three due to its ability to stimulate receptors in the muscle rather than only the cutaneous receptors [22]. The concept is similar to that of IASTM in that sensory receptors located in the muscle can be activated [8,10]. However, plantar massage does not seem to improve dynamic postural control [8,22].

Similar to plantar massage and IASTM, calf massage has been hypothesized to stimulate sensorimotor receptors and, thus, has the potential to improve NMC. LeClaire et al. [8] also assessed static postural control in individuals with CAI using center of pressure with a force plate after they received a calf massage. They found no significant improvement,

which differs from our study's findings. However, it remains unknown how IASTM application to the calf may alter dynamic balance.

4.2. Limitations and Future Research

Despite using a power analysis to determine our sample size, we observed a higher risk of making a type II error for the posteromedial reach and posterolateral reach analyses. Having a larger group of participants could increase statistical power, reducing the risk of a type II error. Secondly, we did not require the participants to be physically active, which limits our ability to generalize our results to an athletic population. Thirdly, we did not have a sham group included in our study. Including a sham group in future research, where IASTM is applied with a small amount of pressure, would allow us to examine a possible neurogenic effect. Finally, consistency in IASTM application pressure to the FL across participants could not be perfectly reproduced. However, the same clinician, trained in IASTM, performed all applications.

In future research, utilizing IASTM on different muscles and comparing the outcomes could help in finding which muscle or muscles should be the primary focus of treatments. Additionally, investigating the effects of IASTM application over time would allow us to determine if the increases in reach distances are maintained for longer periods of time or if they are temporary. Additionally, measuring neural feedback and electrical activity in the FL pre- and post-IASTM application may be beneficial in understanding the effects of IASTM on the neurological level. Finally, future investigations should consider the effects of IASTM on dynamic balance in those without CAI.

5. Conclusions

Application of IASTM to the FL increases YBT anterior reach distance pre- to post-test by approximately 4.45 cm immediately post-treatment. Our results suggest that a single treatment of IASTM to the FL improves dynamic postural control anteriorly in individuals with CAI. Our findings provide a basis for studying the use of IASTM as an injury prevention tool in relation to neuromuscular control because of its ability to stimulate neuromuscular function in patients with CAI. The improvement in anterior reach may be beneficial especially in patients suffering from CAI with anterior reach deficits.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to the terms of the informed consent.

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