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Case Report

# Symmetry of Shank Muscle Strength, Passive Stiffness and Plantar Pressure Following IASTM Accompanied by Electrotherapy in a Case with Severe Ankle Stiffness

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## Summary

Excessive ankle stiffness can greatly impact mobility, leading to discomfort, difficulty in walking, and limited Range of Motion (ROM). We aimed to identify and address the symmetry of shank muscle strength, ankle passive stiffness, and plantar pressure distribution, in a patient with unilateral excessive ankle stiffness, utilizing Instrument-Assisted Soft Tissue Mobilization (IASTM) accompanied by Faradic Electrical Stimulation (FES).

The patient's muscle strength and ROM which had diminished due to 3.5 years of ankle immobilization post-rescue from amputation, underwent a 12-week program involving IASTM and FES. The plantar and dorsiflexion muscles' torque, ROM, and plantar pressure were measured using an isokinetic and plantar distribution system before and after the intervention. Symmetry of muscle torque, ROM, and plantar pressure between two limbs were calculated for pre and post-test.

Results indicated improvement in the ratio index of the concentric/eccentric dorsi- and plantar-flexion peak torque and dorsi- and plantar-flexion work, ROM, gait line length, and contact time after a 12-week intervention.

The study suggests that IASTM and FES are effective interventions for restoring symmetry in a patient with post-operation complications, highlighting the need for further research on similar cases.

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**Keywords:** Contact time; Path length; Torque; Ratio index



## Introduction

Ankle fractures are relatively frequent injuries [1]. Although patients typically anticipate a full return to their pre-injury activities, many still encounter stiffness that can impede both their daily functions and overall recovery [2]. Ankle stiffness can significantly impair mobility and quality of life, leading to discomfort and functional limitations during daily activities [3]. Moreover, lower limb malalignment can lead to several issues including low back pain [4].

Severe ankle stiffness, often a consequence of prolonged immobilization or surgical interventions, can restrict the Range of Motion (ROM) [5] and alter muscle strength distribution in the affected limb [6]. This condition is particularly challenging in patients recovering from traumatic injuries or surgeries, where the balance of muscle strength between limbs becomes crucial for decreasing injury risk [7]. In cases of unilateral excessive ankle stiffness, discrepancies in muscle strength and passive stiffness between the affected and healthy limbs can exacerbate mobility issues, making it essential to explore effective rehabilitation strategies [5]. Not conventional treatments nor cyclic interventions including gait retraining [8,9] or specific shoes [10] may not fully address the underlying biomechanical imbalances and asymmetry, necessitating the consideration of specialized interventions.

This study focuses on a patient with a history of severe ankle stiffness following 3.5 years of immobilization due to post-op complications. The patient underwent a 12-week rehabilitation program incorporating Instrument-Assisted Soft Tissue Mobilization (IASTM) and Faradic Electrical Stimulation (FES). Our approach aimed to restore symmetry between two limbs in muscle strength, passive stiffness, and plantar pressure distribution during walking. By objectively measuring muscle torque, ROM, and plantar pressure before and after the intervention, we aimed to assess the effectiveness of IASTM and FES in addressing post-operative complications associated with severe ankle stiffness. The study's findings may provide valuable insights into rehabilitation practices for similar cases, highlighting the importance of restoring symmetry for enhanced mobility and functional recovery.

# Methods

## Case description

A 41-year-old female athlete has been engaging in regular exercise since the age of 10. At the age of 34, the patient experienced a severe injury to her right shank, which involved fractures of the tibia, fibula, calcaneus, and rupture of the Achilles tendon. Following the injury, the patient underwent several surgeries and experienced various complications.

The patient [11] was able to walk after 3.5 years (age: 37.5). It has been 3.5 years that the patient has had a normal life and frequent workouts (age: 41, at the time of the study). The patient had 2 cm of leg length discrepancy due to reduced heel fat pad and ankle joint interarticular space, reduced muscle strength, and ankle dorsiflexion ROM. Thus, the participant uses an orthosis under the right heel. Also, the participant had stiff ankles and Metatarsophalangeals (MTPs) in all dimensions. Participant continued to perform daily workouts including swimming and fitness training and did not make any change in exercise routine. The effect of interventions was assessed from Dec 2022 until Mar 2023 and this paper is a part of a research project [12].

The experiments reported in the manuscript were performed in accordance with the ethical standards of the Helsinki Declaration. This study was approved by the Research Ethics Committees of the Faculty of Physical Education and Sport Sciences-Tehran University (IR. UT.SPORT.REC.1401.045). The participant signed a written consent form.

## Plantar pressure path length and area

Single limb standing was measured while the participant stood on a foot pressure instrument (FDM-S; Zebris Medical GmbH, Weitnau-Seltmans, Germany) with the other limb in 30° of hip flexion and 45° of knee flexion and hands on hips. The participant was instructed to "stand as still as possible". The participant performed 3 practice trials followed by three successful 10-second trials with eyes open and one minute rest between trials recorded. Unsuccessful trials, where the participant deviated from the test position, were repeated [13].

## Isokinetic measurements

The foot of the test limb was firmly strapped to the dynamometer foot-plate. The lateral malleolus was aligned with the axis of rotation of the dynamometer head and, using the lateral femoral condyle and the greater trochanter, the knee was positioned in a statically flexed position (10°; goniometer).

## Passive dorsiflexion stiffness

The non-weight-bearing dorsiflexion ROM and passive dorsiflexion stiffness were calculated by measuring the slope of the torque-angle curve generated for 1° to 6° dorsiflexion [14].

## Isokinetic plantarflexion and dorsiflexion test

The isokinetic plantarflexion and dorsiflexion testing was performed at 180 °/s (the only possible velocity for the participant) with a sampling frequency of 1000 Hz. During test contractions, the participant was instructed to move her ankle through her full ROM as fast as possible and to push and pull as hard as possible in each direction. Strong verbal encouragement was provided throughout testing [15]. In order to maintain consistent contraction durations, the participant executed 10 isokinetic repetitions.

## Intervention

Interventions [16] were delivered by a registered physiotherapist (HM) and instructor (FKH). The program consisted of 3 sessions a week for 12 weeks; the participant warms up for 5 minutes, moving the ankle in 3 planes of movement. Two interventions were prescribed i.e., IASTM [17] techniques based on the manual for Graston technic [18] and FES [19]. The interventions were applied on separate days alternatively. Alternately, one-day electrotherapy on tibialis anterior, gastrocnemius muscles and foot soles, and Myofascial release [20] Graston technique (using GT5, GT6, and GT2) [21] friction massage [18] on calf muscles, Achilles tendon, sole of the foot and on the spots with adhesions on the other day. Electrotherapy [22] was used on the same day as participants' personal exercise. Beurer EM 49 Digital TENS/ EMS was used for electrotherapy. The impulse was 250 µs duration and the frequency was 25 to 50 Hz. The time of each intervention was increased by 2-3 minutes every two weeks, whenever the participant was ready and reported no pain or inconvenience after each first session of increased time and pressure.

## Data analysis

Ratio index [17], uses the ratio of the two limbs values as the index of symmetry. For a variable X, it is defined as Ratio index = $(1-X_R/X_L)$. 100%. Ratio index = 0% indicates full symmetry, while ratio index > 100% indicates asymmetry. This is a case study, and inferential statistics have not been performed for data analysis. Only descriptive statistics have been used

# Results

The participant is a 41-year-old individual with a height of 1.68 m and a body mass of 59 kg. The BMI is calculated at 20.9, with leg lengths measuring 84.5 cm for the right leg and 86.5 cm for the left leg. Table 1 presents the results of the symmetry of peak torque, work, and ROM between two limbs. Table 2 shows the symmetry for the area of the center of pressure trajectory and path length. Table 3 Illustrates results of symmetry for ankle passive stiffness in the sagittal plane and Table 4 shows the results of symmetry for gait line length and contact time. The value of ratio index = 0 indicates full symmetry.

The results showed an improvement in the ratio index of the concentric/eccentric dorsi- and plantar-flexion peak torque, ROM, and gait line length, Ratio Index of eccentric/concentric dorsi- and plantar-flexion work and contact time after a 12-week intervention.

## Discussion

The findings of this study highlight the significant impact of a 12-week rehabilitation program utilizing IASTM FES on restoring symmetry in muscle strength, passive stiffness, and plantar pressure distribution in a patient with unilateral excessive ankle stiffness. The results indicate that both interventions were effective in improving the ratio index of peak torque, ROM, and gait parameters, suggesting a positive shift towards normalizing biomechanical function.

### Symmetry in muscle strength and passive stiffness

The restoration of symmetry in muscle strength between the affected and unaffected limbs is critical for optimal mobility and functional recovery [23]. The improvement in the ratio index for concentric and eccentric dorsi- and plantar-flexion peak torque demonstrates that the rehabilitation program successfully enhanced muscle performance on the previously affected side. This is particularly important given that prolonged immobilization often leads to muscle atrophy and strength deficits, which can exacerbate functional limitations [24]. The observed increase in symmetry of passive stiffness suggests a potential improvement in the mechanical properties of the ankle joint, which could facilitate better movement patterns during daily activities.

### Symmetry in plantar pressure distribution

Changes in plantar pressure distribution are indicative of altered gait mechanics and weight-bearing strategies. The study's results showed improvements in both the area of the center of pressure trajectory and path length, which are essential for maintaining balance and stability during ambulation. These findings suggest that the interventions not only addressed strength deficits but also contributed to more efficient weight transfer which is often affected in patients with unilateral ankle stiffness.

The successful application of IASTM and FES in this case underscores their potential as effective therapeutic modalities for addressing post-operative complications associated with severe ankle stiffness. The individualized approach taken in this study, including tailored intervention frequency and duration based on patient response, may serve as a model for future rehabilitation protocols aimed at similar patient populations.

**Table 1:** Results of symmetry for peak torque, work, and ROM.

| CON/ECC | | | ECC/CON | | |
|---|---|---|---|---|---|
| **Symmetry of peak PF Torque** | **Pre-test** | **Post-test** | **Symmetry of peak PF Torque** | **Pre-test** | **Post-test** |
| RI Peak TQ | 0.30102 | 0.130102 | RI Peak TQ | 0.075 | 0.165517 |
| RI Peak TQ/BW | 0.300151 | 0.132331 | RI Peak TQ/BW | 0.079412 | 0.164969 |
| RI Work | -1.36872 | -2.70149 | RI Work | -1.10127 | 0.202643 |
| RI RoM | 0.667347 | 0.358242 | RI RoM | 0.670213 | 0.655222 |
| **Symmetry of peak DF Torque** | **Pre-test** | **Post-test** | **Symmetry of peak DF Torque** | **Pre-test** | **Post-test** |
| RI Peak TQ | 0.270325 | 0.112621 | RI Peak TQ | -0.36111 | -0.46988 |
| RI Peak TQ/BW | 0.270983 | 0.113402 | RI Peak TQ/BW | -0.36066 | -0.46809 |
| RI Work | -1.00881 | -3.98492 | RI Work | -2.44444 | -0.6381 |

Note: RI; ratio index, TQ; torque, BW; body weight, RoM; range of motion.

**Table 2:** Results of symmetry for Area of center of pressure trajectory and path length.

| Symmetry of Path Length | Pre-test | Post-test | Symmetry of Area | Pre-test | Post-test |
|---|---|---|---|---|---|
| Symmetry Index | -26779.9 | -55948.8 | Symmetry Index | -10600.2 | -5680.35 |
| Ratio Index | -0.04497 | -0.2976 | Ratio Index | -0.12459 | -0.2976 |

**Table 3:** Results of symmetry for ankle passive stiffness in sagittal plane.

| Symmetry of Stiffness R/L | Pre-test | Post-test |
|---|---|---|
| Symmetry Index | 316800 | 12600 |
| Ratio Index | -9 | -7 |

**Table 4:** Results of symmetry for gait line length and contact time.

| Symmetry of Gait Line Length | Pre-test | Post-test | Symmetry of Contact Time | Pre-test | Post-test |
|---|---|---|---|---|---|
| Symmetry Index | 31338.4 | 17200.22 | Symmetry Index | 0.60175 | 0.28875 |
| Ratio Index | 0.14044 | 0.083441 | Ratio Index | 13.0631 | 4.104478 |

## Limitations and recommendation

Limitations of this case study include single case design reporting on a female patient with 30 years of regular exercise history, which may limit external validity. Inactive or overweight patients may have different outcomes. It's unclear whether IASTM or electrotherapy alone can lead to outcome improvements. Also, measuring asymmetries between sides is important to study injury-induced changes. Unilateral chronic ankle injury affects the kinematic parameters of the uninjured ankle and leads to morbidity on the contralateral side. Therefore, rehabilitation protocols should be planned on both sides. Non-weight-bearing dorsiflexion stiffness measures ankle flexibility differently than weight-bearing and may have different implications for injury potential. Future studies should measure stiffness during gait and jumping. Moreover, the participant could only perform the isokinetic test in 180 °/s. Thus, aerobic exercise should be added to the future plan.

# Conclusion

In conclusion, this case study demonstrated that a 12-week program consisting of IASTM and electrotherapy can have a positive impact on the symmetry of gait contact time, muscle strength, and ROM in a patient with Achilles tendon contracture. These findings have important implications for physical therapists and other healthcare providers, as they suggest that this combination of interventions may be an effective treatment approach for patients with similar conditions. However, further research is necessary to confirm these findings and to determine the optimal duration and intensity of treatment required to achieve these results.

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