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Integrated Neuromuscular Inhibition Technique versus Instrument Assisted Soft Tissue Mobilization in Patients with Chronic Plantar Fasciitis

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ABSTRACT
Background: Plantar fasciitis (PF) is a condition characterized by the plantar fascia's deterioration, which is brought on by constant strain at the calcaneus, where it attaches. This leads to heel pain and functional impairment.
Purpose: to compare between integrated neuromuscular inhibition technique (INIT) as well as instrument assisted soft tissue mobilization (IASTM) in treatment patient with chronic PF.
Patients and Methods: A total of 54 participants, comprising both genders aged between 40 and 60 years, were randomly divided into three groups. Group (A): got conventional treatment of PF. Group (B): got conventional treatment in addition INIT. Group (C): got conventional treatment in addition IASTM. Each group received 4 weeks' treatment; 3 sessions per week. Pain intensity level, pain pressure threshold (PPT), active ankle dorsiflexion ROM (range of motion) and foot functional disability level were measured using visual analogue scale, electrogoniometer, pressure algometer, and foot disability index in Arabic.
Results: There was a significant difference decrease in mean value of pain and foot function index (FFI), increase in mean value of pressure pain threshold (PPT) and ankle dorsiflexion ROM within three groups. Post hoc test conducted between groups reveled a favor of INIT group program (Group B) followed by IASTM group program (Group C) in all variables.
Conclusion: Conventional treatment, INIT, and IASTM were effective to decrease pain and score of FFI, increase PPT and dorsiflexion ROM with superiority of INIT group (Group B) followed by IASTM group (Group C).
Keywords: Plantar fasciitis, integrated neuromuscular inhibition technique, instrument assisted soft tissue mobilization, visual analogue scale, Pressure algometer.

INTRODUCTION
Plantar fasciitis (PF) results from repetitive damage at the plantar fascia's point of attachment on the heel bone, which causes the ligament in the foot to degenerate, Collagen deterioration in the calcaneus medial tubercle, the origin of the plantar fascia, is typically the cause of pain. It affects 10% of the overall population. Functional risk factors are weakness in the intrinsic foot muscles and tension in the gastrocnemius and soleus muscles. These attributes lead to restricted dorsiflexion, which stresses the plantar fascia because of the Achilles tendon rigidity [(1)].

The sensation of pain is more severe in morning initial steps or after a prolonged period of avoiding activities that put weight on the affected area. Frequently, the pain subsides after taking a few steps and during the day, but comes back when engaging in strong or extended weight-bearing activities [(2)].

Risk factors for mechanical overloading of the plantar fascia include obesity, reduced dorsiflexion ROM, and tightness of calf muscles. gastrocnemius muscle stiffness is a frequent cause of reduced ankle dorsiflexion ROM [(3)].

Integrated neuromuscular inhibition technique (INIT) includes three manoeuvres, which are integrated into a single approach. The three methods are muscular energy technique (MET), strain counter strain technique, and ischemia compression (IC), often known as trigger point release. Compressing the trigger point region is necessary for trigger point release, while holding it for 5 seconds then released for 5 seconds, that enhances blood supply whereas strain counter strain technique involves stretching the superficial fascia that induces muscular relaxation. MET operates on the basis of reciprocal inhibition that reduces muscle tone [(4,5)]. Instrumented assisted soft tissue mobilization (IASTM) is the utilization of a specifically developed tool to manipulate soft tissue in order to alleviate pain and enhance ROM and functionality. IASTM makes it easier for the physician to reach the fascia and releases constrictions by reducing hand strain and enabling more complete penetration [(6)].

To the available knowledge, there is no study comparing effects of INIT and IASTM in the treatment of chronic PF. Thus, this study's goal was to contrast the impacts of INIT and IASTM with regard to pain intensity in morning initial step, pain pressure threshold (PPT), active ankle dorsiflexion ROM, and foot functional disability.

PATIENTS AND METHODS
A. Study design and sample size calculation:
This study was conducted from November 2023 to May 2024 at the Outpatient clinic of El Set Khadra Hospital in Helwan, Egypt. A randomized controlled trial study design was conducted including three treatment groups. G*Power (3.1.9.7) was used for the purpose of calculating the sample size. With a total of 54 patients divided into three groups and four dependent variables, the study's power was set at 0.8 with the alpha error of probability (α) at 0.05.

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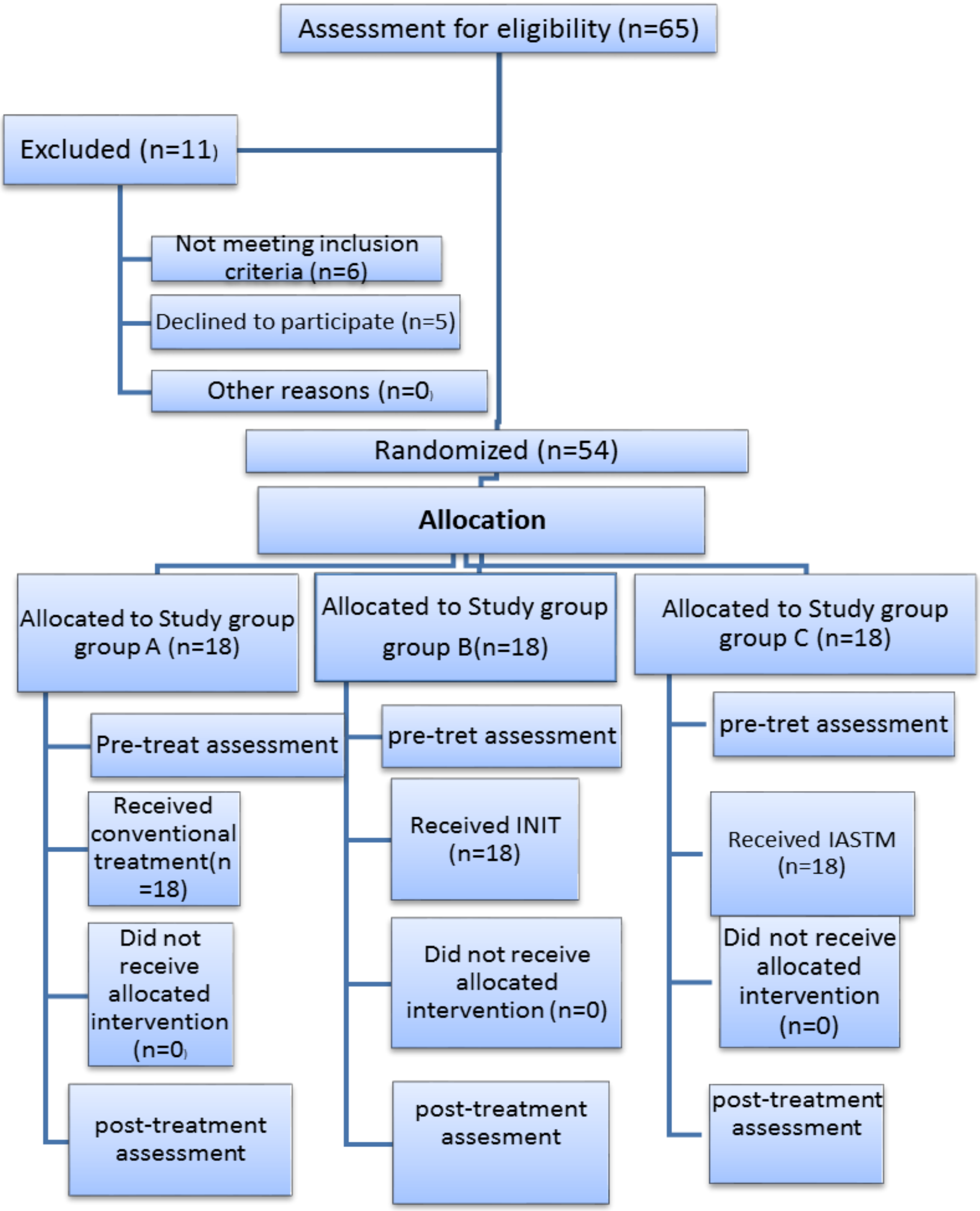

Figure (1) Flow chart of the study participants**.**

B. Inclusion criteria:

Participants were included in the study if their history of plantar fasciitis was more than three months ago, plantar heel pain with first few steps upon walking in the morning and after prolonged rest [7], increased heel pain after weight bearing activity, the pain is localized at the heel or the plantar surface of the foot, which is indicative of PF, with at least one identifiable MTrP within the gastrocnemius muscle, in addition to patients from both genders, the patient's age was within the range of 40 to 60 years [8] and patient's body mass index (BMI) was 18 to 29.9 kg/m^2 [9].

C. Exclusion criteria:

If a participant showed any warning signs, they were not included in the study, i.e., presence of a tumour, fracture, or heterotrophic ossification, as well as an acute inflammatory condition in the ankle-foot region. In addition, participants with foot and ankle complex deformities, those with a history of surgery on the distal tibia, fibula, ankle joint, or back foot area, and those with referred pain from sciatica or another neurological condition were also excluded[9].

D. Participants preparation and randomization:

To avoid selection bias, the patients were randomly allocated by simple random method via choosing one of three wrapped cards representing the three treatment groups. Fifty-four eligible participants (10 males and 44 females) were allocated into three equal groups:

Control group (A): included 18 participants (3 males and 15 females). Received conventional therapy in the form of home education program, therapeutic ultrasound and planter fascia stretch.

Experimental group (B): included 18 participants (4 males and 14 females). received INIT in addition to conventional treatment.

Experimental group (C): included 18 participants (3 males and 15 females). received IASTM and conventional treatment.

-All treatment lasted for 3 sessions per week for 4 weeks.

E. Measurement scales and instrumentations:

1. Calibrated weight-height scale used to measure the weight and height to calculate BMI for each patient.
2. Visual analog scale (VAS): a horizontal line that is 100 mm long and has word descriptions at either end. The VAS score is determined in millimeters (mm) starting at the left end of the line and going all the way to the patient's mark.
3. Wagner Instruments' FPX 25 pressure algometer (Greenwich, CT, USA): Used to evaluate PPT (tenderness) over the lower medial trigger point in gastrocnemius muscle of the involved heel.
4. Electro goniometer: Used to measure active ankle dorsiflexion ROM.
5. The foot function index scale in Arabic: The 23 self-reported elements in the FFI (questionnaire) are broken down into three divisions based on patient values: pain, disability, and activity limitation. Each question asks the patient to rate how well their foot has been feeling over the last week on a scale of 0 (no pain or difficulty) to 10 (worst pain imaginable or so terrible that requires help). The nine items in the pain subcategory are used to quantify foot pain in various scenarios, such as walking barefoot versus wearing shoes. The disability subcategory comprises nine items that assess the degree of difficulty in carrying out different functional activities due to foot issues, like climbing stairs. The five items in the activity limitation subcategory indicate activities that are restricted due to foot issues, such as spending the entire day in bed.

F. Treatment instrumentations:

1. **Ultrasound device:** As a therapeutic ultrasound, the CWM302 Chungwoo Medical, South Korea, 2001 can stimulate material renewal of the treated area by means of a 1MHz or 3MHz ultrasonic pulse with thermal effects.
2. **Tool for soft tissue mobilization with instrument assistance: M2T blade:** a latest invention, which helps us to release myofascial pain using the M2T blade.

G. Clinical evaluation:

1) Detection of myofascial trigger points: MTrPs were identified either through a flat palpation technique or pincer palpation. The recommended diagnostic criterion for MTrPs was used, that was as follows: A. Feeling the presence of a tight band in the muscular tissue. B. Existence of a highly sensitive area within the taut muscle fiber. C. Snapping palpation is applied to elicit the local twitch response. D. Trigger point compression can induce a characteristic referred pain pattern. E. The characteristic referred pain pattern just happens on its own. The trigger points were categorized as latent if the first four requirements were satisfied. If all four criteria were met, the trigger points were classified as active.

2) Measurement of pain intensity level: the measurement was obtained using a VAS, where the patient was instructed to indicate their perception of their current state by marking a point on a line.

3) Measurement of pain pressure threshold: It was measured using the manual algometer on the MTrPs then increase pressure by 1 kg/cm per second until the subject felt a sensation of pain guided by using a standard metronome. Once the patient felt pain, the patient said "now" so, the level of pressure was recorded. It was measured three times with 30 seconds between each then the mean value of measurement was reported.

4) Measurement of active ankle dorsiflexion ROM: It was measured using the digital angular goniometer. The patient assumed supine position with foot on the plinth then patient asked to dorsiflex his ankle. The mean value of successive three trials was recorded as a measurement for ankle dorsiflexion.

5) Measurement of foot functional disability level using the Arabic version of foot functional disability index:

The patient was relaxed and asked to complete the FFI before and after the period of intervention.

H. Treatment procedures:

Control Group (A): received conventional physical therapy program that included:

1. Home education program:

Advice: Avoid wearing tight shoe, avoid standing for long period of time, Orthosis: Use an orthosis (heel pads, heel cups) [10].

Exercise: Strengthening of intrinsic foot muscles, self-stretching of calf muscle using a towel, and ice massage using a frozen bottle.

a) **Intrinsic muscle exercises:**
- For five minutes, rolled a tennis ball under the feet in all directions forward, backward, and sideways [11].
- Exercises involving the toes and towel holding (curls) improve the intrinsic foot muscles. On a smooth surface, the patient sat with their foot flat on a towel. For five minutes, curl the towel through the toes, keeping the heel firmly on the floor. This brings the towel closer to the body [11].

b) **Self-stretching of calf muscle using a towel:** patient sat with the affected leg straight out on the bed. patient's foot wrapped in a towel and pulled it close to patient's face until the patient feels a stretch in their calf muscle. Maintained for 45 seconds, repeating 2-3 times. Repeat 4-6 times daily [11].

c) **Ice Massage:** foot placed over frozen bottle of water and rolled it back and forth for a duration of 10 minutes, twice day [11].

2. Therapeutic ultrasound: frequency (1MHz), the output of 1.5W/cm^2 for 7 minutes

3. Plantar fascia stretching: The therapist placed the patient in a supine position and used one hand to hold the patient's heel, maintaining the subtalar joint in a neutral position. The therapist grasped the metatarsal area with the other hand. Next, gentle pressure towards the shin was applied until the patient experiences a stretching sensation in plantar fascia. The pose was held for a minimum of 15 to 30 seconds and was repeated three times.

Experimental group (B): got INIT plus conventional treatment, three sessions weekly for a duration of four weeks.

INIT included IC, SCS, and MET for the gastrocnemius muscle. IC was given by the therapist on the lower medial trigger point of gastrocnemius muscle while the subject lied face down on a treatment table having their feet dangled off the edge, while therapist gave pressure on TrP and maintained it for 5 second then released for 5 second. This procedure was repeated 3 times [12], then SCS technique was applied in which the participant was passively positioned in a comfortable position in the prone laying posture, ankle plantarflexed and knee flexied 90 degrees. After the therapist has palpated the trigger point, therapist applied and held deep manual pressure for 90 seconds. This step was repeated three times [13]. Following that, the participant underwent the MET, during which they were positioned in a supine posture with their knee extended in order to target the gastrocnemius muscle. The subject's ankle joint was manually dorsiflexed by the therapist until participant felt resistance or discomfort. This position requires the participant to apply force (isometric contraction) equivalent to approximately 20% of their maximum strength to perform plantar flexion for a duration of 7 to 10 seconds, while maintaining proper breathing. After this, the resistance was gradually released, 5-second relaxation period was allowed. During this relaxation period, the ankle was gently moved to a new position of dorsiflexion and held in that stretched position for 15 to 30 seconds. The complete sequence was repeated 5 times [9].

Experimental group (C) got IASTM plus conventional therapy, three sessions weekly for a duration of four weeks.

IASTM group participants were assumed prone position on treatment table, with feet outside the table. The therapist used little amount of emollient onto the gastrocnemius muscle. Participants were directed to offer feedback to the therapist to supervise treatment intensity and ensure patient comfort. Convex, sharp edge of IASTM tool was positioned in direct contact with the gastrocnemius muscle at a 45° angle. IASTM was used to treat area of restrictions for a duration of 30-60 seconds per lesion. This was done by applying sweep and fan strokes in numerous directions [14].

Ethical approval:

Clinical trials.gov (ID: NCT06493487) was used to register the study protocol, and the Faculty of Physical Therapy at Cairo University in Egypt granted Ethical Committee permission with number P.T.REC/012/004961. Prior to their involvement in the study, every participant signed a written consent form.

Statistical analysis: The Shapiro-Wilk test was employed to assess the normality of the data. The SPSS package application, version 25 for Windows (SPSS, Inc., Chicago, IL), was used to conduct the statistical analysis. Quantitative data were represented by the mean and standard deviation (SD) and were compared by one-way ANOVA test or MANOVA test. When a pairwise comparison of the tested variables between and within groups yields a significant P-value from a MANOVA test, the Bonferroni correction test was employed. Qualitative data were represented as frequency (%) and were compared by chi-square test. There was statistical significance in all analyses at the 0.05 level of probability ($P < 0.05$).

RESULTS

There were no statistically substantial differences in the clinical general characteristics of patients with chronic PF (Table 1).

Table 1. Clinical general characteristics of chronic plantar fasciitis patients

Items	Groups (Mean ±SD)			*P*-value
	Group A (n=18)	Group B (n=18)	Group C (n=18)	
Age (year)	47.72 ±6.30	46.72 ±7.02	49.17 ±7.07	0.560
Weight (kg)	72.67 ±8.52	73.56 ±9.56	76.33 ±7.52	0.415
Height (cm)	163.44 ±7.09	164.67 ±7.21	162.50 ±9.39	0.717
BMI (kg/m^2)	27.16 ±2.15	26.85 ±3.33	28.12 ±2.00	0.309
Gender (males : females)	3 (16.70%) :15 (83.30%)	4 (22.20%):14 (77.80%)	3 (16.70%):15 (83.30%)	0.885

BMI: body mass index, Group A: control group; Group B: INIT group; Group C: IASTM group
Quantitative data are reported as mean ±standard deviation and compared by ANOVA test. Qualitative data are reported as frequency (percentage) and compared by Chi-square test.

Within group comparison

Following treatment, all three groups exhibited significant reduction in pain intensity in morning initial step, and ankle disability function score and increased in pain pressure threshold and active ankle dorsiflexion ROM (Table 2).

Between group comparison

post treatment there was a statistically significant decreases in mean values of pain intensity in morning initial step, and ankle disability function score and significant increases in pain pressure threshold and active ankle dorsiflexion ROM with favorable of patients with chronic PF in Group B, followed by Group C, and then Group A **(Table 2)**.

Table 2. Within and between group comparison for main variable outcomes

Variables	Items	Groups (Mean ±SD)			*P*-value^2
		Group A (n=18)	Group B (n=18)	Group C (n=18)	
Pain intensity in morning initial step	Before-treatment	8.83 ±1.15	8.50 ±1.08	8.33 ±0.97	0.874
	After-treatment	5.56 ±0.70	4.39 ±0.91	4.44 ±0.92	0.0001*
	MD (Change)	3.27	4.11	3.89	
	95% CI	2.63 – 3.91	3.30 – 4.92	2.91 – 4.87	
	Improvement %	37.03%	48.35%	46.70%	
	P-value^1	0.0001*	0.0001*	0.0001*	
Pain pressure threshold	Before-treatment	0.97 ±0.18	0.97 ±0.17	0.98 ±0.14	0.983
	After-treatment	3.04 ±0.37	3.40 ±0.37	3.25 ±0.36	0.001*
	MD (Change)	2.06	2.43	2.26	
	95% CI	1.87 – 2.25	2.24 – 2.62	2.07 – 2.45	
	Improvement %	213.40%	250.52%	231.63%	
	P-value^1	0.0001*	0.0001*	0.0001*	
Active ankle dorsiflexion ROM	Before-treatment	15.21 ±1.68	16.09 ±3.02	16.33 ±2.25	0.442
	After-treatment	24.53 ±3.60	27.60 ±2.08	25.55 ±3.43	0.001*
	MD (Change)	9.32	11.51	9.21	
	95% CI	7.48 – 11.15	8.67 – 14.35	7.37 – 11.04	
	Improvement %	50.21%	71.54%	67.98%	
	P-value^1	0.0001*	0.0001*	0.0001*	
Ankle disability function score	Before-treatment	151.06 ±20.33	148.78 ±16.67	151.56 ±12.92	0.653
	After-treatment	64.44 ±11.62	58.33 ±8.00	60.72 ±10.19	0.007*
	MD (Change)	86.62	90.45	90.84	
	95% CI	81.13 – 92.11	81.24 – 99.64	87.91 – 93.77	
	Improvement %	57.34%	60.79%	59.94%	
	P-value^1	0.0001*	0.0001*	0.0001*	

Group A: control group; Group B: INIT group; Group C: IASTM group
Data are expressed as mean ±standard deviation and compared statistically by MANOVA test. MD: Mean difference. CI: confidence interval *: Significant. P-value^1: Probability value within each group; P-value^2: Probability value among groups

The post-hoc test and mean differences among groups revealed that the INIT group program (Group B) followed by IASTM group program (Group C) gave the best values of pain intensity in morning initial step, pain pressure threshold, active ankle dorsiflexion ROM, and ankle disability function score **(Table 3).**

Table 3. Pairwise comparison (Post-hoc test) between groups for main variable outcomes after-treatment

Variables	Items	Post-hoc test (after-treatment)		
		Group A *vs.* Group B	Group A *vs.* Group C	Group B *vs.* Group C
Pain intensity in morning initial step	MD	1.17	1.12	0.05
	P-value	0.001*	0.003*	1.000
Pain pressure threshold	MD	0.36	0.21	0.15
	P-value	0.001*	0.102	0.317
Active ankle dorsiflexion ROM	MD	2.07	1.01	1.05
	P-value	0.001*	0.423	0.419
Ankle disability function score	MD	6.11	3.72	2.39
	P-value	0.001*	0.021*	0.249

Group A: control group; Group B: INIT group; Group C: IASTM group
Data are expressed as mean difference and compared statistically by Bonferroni correction test.
P-value: probability value between pairwise groups (post-hoc test). MD: Mean difference, *: Significant.

DISCUSSION

This research was directed to compare the efficacy of INIT and IASTM in the refinement of pain intensity in morning initial step, pain pressure threshold, active ankle dorsiflexion ROM, and ankle disability function among chronic PF patients.

All the outcome measures were evaluated using valid as well as reliable tools. The measurement of pain intensity was conducted using the VAS, a validated and reliable tool for assessing pain intensity [(15)]. PPT was measured by digital algometry, which is a valid and reliable tool to assess MTrPs [(16)]. Active ankle dorsiflexion ROM was measured by electrogoniometer device which is considered a valid and reliable tool to measure dorsiflexion ROM. Functional disability was measured by FFI which is a valid, reliable, and responsive tool that can be used to assess foot function in the Arabic-speaking populations [(17)].

The first hypothesis in this investigation suggested that there is no statistically substantial difference among INIT versus IASTM in pain intensity in morning initial step among patient with chronic PF. According to the results of this study this hypothesis was rejected as there was a substantial difference among the three groups in pain intensity in morning initial step ($P<0.05$). The INMIT group program (Group B) followed by IASTM group program (Group C) gave the best values.

The outcomes of this study are aligned with a similar study of **Sibby *et al.*** [(18)] who stated that INIT has a significant improvement in pain in controlling the trigger sites in the upper trapezius. **Thakur *et al.*** [(19)] examined the efficacy of INIT compared to IASTM in treating MTrPS in the upper trapezius muscle. The researchers determined that INIT is superior to IASTM in treating upper MTrPS.

The patients who underwent INIT plus conventional treatment (group B) experienced improvements due to the culmination of the three manual therapy modalities. Intermittent IC mostly reduces pain by activating A-beta fibers, which are involved in the feeling of pain, improving circulation upon pressure release. Furthermore, strain counter strain technique can relief pain, enhance functionality, and increase ROM by positioning the muscle in a passive shortened position. This position facilitates the restoration of regular muscle spindle activity and enhances blood circulation to the muscle. Ultimately, the MET is crucial in reducing pain, enhancing function, and increasing ROM by targeting the autogenic inhibition of muscles. This method applies isometric muscle contraction, which causes the Golgi tendon organ to become active and causes the muscles to relax. In addition, MET plays a crucial role in enhancing the ROM through alterations in muscle extensibility, such as reflex relaxation, viscoelastic changes, and stretch modifications [(5)]**.**

Numerous processes account for the benefits shown in patients who received IASTM using the M2T blade. Firstly, when an instrument is used to scrape the skin, it causes removal and loosening of scar tissues and adhesions. Secondly, it also induces vasodilation response, an increase in tissue temperature, and local inflammation. Thus, there is an increase in blood flow to the area which provides oxygen, nutrients supply, and removes metabolic endproducts and inflammatory mediators. It improves fibroblastic activity and proliferation, collagen synthesis, orientation and development and, as a result, the process of healing. The manual muscle treatment could be considered as anti-inflammatory by raising mediators that are anti-inflammatory [(20)]**.**

Nadeem *et al.* [21] exhibited the impact of the Ergon IASTM technique on pain, strength, among patients with PF. IASTM proved to be a highly successful treatment method for lowering pain.

The second hypothesis of this investigation suggested that there is no statistically substantial difference among INIT vs IASTM on PPT in patient with chronic PF. Based on the outcomes of this study we rejected this hypothesis as there was a substantial difference among the three groups as the INIT group program (Group B) followed by IASTM group program (Group C) gave the best values.

The outcomes of this study are aligned with a similar study of **Hamdy *et al.*** [22] who compared the effect of IASTM versus INIT in nonspecific chronic neck pain, all variables showed improvement in all groups, with the INIT group demonstrating greater improvement in PPT.

The third hypothesis of this investigation suggested that there is no statistically substantial difference between INIT vs IASTM on active dorsiflexion ROM among patient with chronic PF. Based on the result of this investigation we rejected this hypothesis as there was a substantial difference among the three groups as the INIT group program (Group B) followed by IASTM group program (Group C) gave the best values.

The results agreed with **Tanwar *et al.*** [1] who conducted a study on the efficacy of MET in enhancing the flexibility of the gastro-soleus complex in individuals with PF. MET was superior in alleviating pain, enhancing ROM, and increasing foot functional index in PF.

Pawar *et al.* [23] conducted a study on the effect on PF of strain-counter-strain. They demonstrated the efficacy of the treatment in individuals suffering from PF resulting in an improvement of the restricted range of ankle dorsiflexion.

The fourth hypothesis of this study suggested that there is no statistically substantial difference among INIT vs IASTM on functional disability of ankle joint among patient with chronic PF. Based on the findings of this investigation we rejected this hypothesis as there was a substantial difference among the three groups as the INIT group program (Group B) followed by IASTM group program (Group C) gave the best values.

The results agreed with **Am *et al.*** [24] who provided the comparison between myofascial release and positional release therapy in PF. There was reduction in pain and an enhancement in functional abilities.

Mundhava [12] investigated the impact of MET compared to IC on pain and disability among individuals with PF. Both were beneficial in enhancing flexibility and strength.

The objective of plantar fascia specific stretching is to alleviate the constriction in the fascia and regain original length of the tissue. It is believed that gentle and prolonged stretching can release adhesions and relax the fascia, improve blood flow, and relief nerve compression. The plantar fascia specific stretch was identified as the most effective method for minimizing morning pain [23].

The calf stretching procedure, as recommended by **Michelsson *et al.*** [25] in their study, is a successful technique for increasing function in PF. The reason for calf stretching in PF is to enhance ROM in dorsiflexion, which alleviate tension on the plantar fascia during the push-off phase of walking cycle.

One of the best ways to manage heel pain has been shown to be strengthening the intrinsic foot muscles. The strong intrinsic muscles play a crucial role in providing support to the foot's arches [11].

LIMITATIONS

This study delimited by the following:

- The interventions lasted for four weeks, and no follow-up was conducted to determine their long-term impact.
- Small sample size.
- Psychophysiological factors, which may have interfered with the subjects' performance and response.

CONCLUSION

Conventional treatment, INIT, and IASTM were effective to decrease pain and score of FFI, increase PPT and dorsiflexion ROM with superiority of INIT group (Group B) followed by IASTM group (Group C).

Authors contributions:

The authors cooperated in the article drafting and approved the final version submission for online publication.

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Conflict of interests:

The authors declare no conflict of interest.

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