

COMPARATIVE EFFECTIVENESS OF EXTRACORPOREAL SHOCKWAVE THERAPY, INSTRUMENT ASSISTED SOFT TISSUE MOBILIZATION, AND HIGH-INTENSITY LASER THERAPY ON PAIN AND FUNCTIONAL OUTCOMES IN PLANTAR FASCIOPATHY: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT:

Background: Plantar fasciopathy is a common cause of heel pain resulting from degenerative changes in the plantar fascia, leading to pain and functional impairment. Although extracorporeal shockwave therapy (ESWT), instrument-assisted soft tissue mobilization (IASTM), and high-intensity laser therapy (HILT) are widely used, comparative evidence remains limited.

Objective: To compare the effectiveness of ESWT, IASTM, and HILT in reducing pain and improving function in individuals with plantar fasciopathy.

Methods: In this single-center, parallel-group randomized controlled trial, 60 participants with plantar fasciopathy were randomly assigned to ESWT, IASTM, or HILT (n = 20/group). Interventions were delivered for 4 weeks with a standardized home exercise program. Outcomes included the Numeric Pain Rating Scale (NPRS), Heel Tenderness Index (HTI), Foot and Ankle Outcome Score (FAOS), and Foot Function Index (FFI), assessed at baseline, 4 weeks, and 12 weeks. Mixed repeated-measures ANOVA with Bonferroni-adjusted post hoc testing evaluated time, group, and time × group effects.

Results: A significant main effect of time was observed for all outcomes ($p < 0.001$), whereas no significant main effect of group was found. Time × group interactions were not significant for NPRS or HTI but were significant for FAOS and FFI. At 12 weeks, ESWT and IASTM demonstrated greater functional improvement than HILT, with no significant difference between ESWT and IASTM.

Conclusion: All three modalities effectively reduced pain and heel tenderness. However, ESWT and IASTM produced superior medium-term functional outcomes compared with HILT, suggesting greater clinical benefit through restoration of plantar fascia biomechanics.

KEYWORDS: Plantar fasciopathy, extracorporeal shockwave therapy, instrument-assisted soft tissue mobilization, high-intensity laser therapy, randomized controlled trial, functional outcomes.

INTRODUCTION

Plantar fasciopathy is one of the most prevalent causes of heel pain in adults, accounting for a significant proportion of foot-related clinical presentations.¹ It is usually presented with localized pain over the medial calcaneal tubercle, with pain being most severe during the first few steps after rest, and may improve with activity but then worsen again with prolonged weight bearing.

Plantar fasciitis is a legacy name for this condition, derived from the idea that it is an inflammatory disorder. However, it is now more commonly understood to be a degenerative disorder and is now referred to as plantar fasciopathy.² This condition involves microtears, collagen disorganization, and reduced vascularity within the plantar fascia, leading to impaired tissue healing and persistent symptoms.

Biomechanically, the plantar fascia has an important role in maintaining the medial longitudinal arch with the windlass mechanism.³ During gait, toe dorsiflexors increase tension within the fascia, contributing to arch stabilization and efficient load transfer. Repetitive mechanical loading, especially in individuals with altered foot biomechanics or prolonged standing and ambulation, can lead to cumulative microtrauma and eventual degeneration of the plantar fascia. A wide range of conservative treatment strategies have been proposed for plantar fasciopathy, including stretching protocols, orthotic support, pharmacological management, and various physiotherapeutic modalities. Among these, extracorporeal shockwave therapy (ESWT), instrument-assisted soft tissue mobilization (IASTM), and high-intensity laser therapy (HILT) have gained increasing clinical attention due to their potential to address both symptoms and underlying tissue pathology.

ESWT is believed to promote neovascularization, enhance tissue regeneration, and modulate nociceptive pathways.^{4,5} In contrast, IASTM applies controlled mechanical stress to soft tissues, facilitating fibroblast activation and collagen remodeling, thereby improving tissue mobility.^{6,7} HILT utilizes high-energy laser application to penetrate deep tissues, inducing photobiomodulation effects that may reduce pain and support cellular repair processes.^{8,9}

Despite the growing utilization of these modalities in clinical practice, there remains limited evidence directly comparing their relative effectiveness, particularly in terms of both pain reduction and functional improvement over time. Understanding the comparative benefits of these interventions is essential for optimizing treatment strategies in individuals with plantar fasciopathy.

Therefore, the present study aimed to compare the effectiveness of ESWT, IASTM, and HILT in reducing pain and improving functional outcomes.

METHODOLOGY

This single-center, parallel-group randomized controlled trial was conducted in a tertiary care hospital. A total of 60 participants aged between 20 and 55 years presenting with heel pain of more than 6 weeks duration were recruited. Both male and female participants were included. Participants were randomly allocated using a computer-generated sequence. Written informed consent was obtained from all participants before inclusion in the study.

A detailed clinical history and physical examination were performed. The diagnosis of plantar fasciopathy was established based on localized tenderness at the medial calcaneal tubercle and pain during the first steps in the morning, which increased with weight-bearing activities.

2.1 Inclusion Criteria

- Participants were included when they met the following criteria:
- Pain reproducible on palpation of the plantar fascia
- Localized, non-radiating heel pain
- Pain aggravated during initial steps after a period of rest
- Symptoms persisting for more than 6 weeks
- Inadequate response to conservative management, including rest, stretching, silicone insoles, and non-steroidal anti-inflammatory drugs

2.2 Exclusion Criteria

Participants were excluded if they had:

- History of corticosteroid injection in affected foot
- Previous surgery involving the foot or spine, including lumbar disc pathology
- Rheumatological disorders such as rheumatoid arthritis, spondyloarthritis, gout, or systemic lupus erythematosus
- Clinical signs of acute inflammation, including redness, warmth, swelling, deformity, or skin changes

2.3 Randomization and Group Allocation

Participants were randomly allocated into three groups (n = 20 per group):

- Group A: Extracorporeal Shockwave Therapy (ESWT)
- Group B: Instrument-Assisted Soft Tissue Mobilization (IASTM)
- Group C: High-Intensity Laser Therapy (HILT)

Outcome measures were recorded at baseline, at 4 weeks (post-intervention), and at 12 weeks (follow-up). A single Sports Physiotherapist administered all the treatment modalities and measured all the outcomes. No analgesics or orthoses were prescribed.

2.4 Intervention Protocol

Group A – ESWT

Extracorporeal shockwave therapy was administered using radial shockwaves. Before application, ultrasound coupling gel was applied to facilitate optimal transmission. The area of maximal tenderness was identified clinically. Treatment was delivered at the calcaneal insertion of the plantar fascia and surrounding regions using the following parameters: 2.5 bar pressure, 10 Hz frequency, and 2000 shocks per session. No anesthesia was used. Sessions were conducted once weekly for 4 weeks.^{2,3}



Figure 1: Application of Extracorporeal Shockwave Therapy (ESWT)

Group B – IASTM

IASTM was performed with the participant in a prone position with the feet extending beyond the treatment table. A small amount of emollient was applied to reduce friction. The sweep technique was used, applying approximately 60–70 strokes per minute at an angle of 60°, targeting the plantar surface from the medial calcaneus to the metatarsal heads. Areas of increased tissue restriction were treated with greater intensity within patient tolerance. Each session lasted approximately 8 minutes, followed by application of a cold pack for 5 minutes. Two sessions per week were administered for 4 weeks. 4,5



Figure 2: Application of Instrument Assisted Soft Tissue Manipulation (IASTM)

Group C – HILT

High-intensity laser therapy was administered using a Class IV Nd:YAG laser with a wavelength of 1064 nm. Treatment was delivered in continuous mode with an energy density of 120 J/cm² and a total energy of 3000 J per session. A 10 mm applicator with a beam area of 25 cm² was used, and the power output was set at 7 W. Each session lasted approximately 7 minutes. Three sessions per week were administered over a period of 4 weeks. 6,7



Figure 3: Application of High Intensity laser Therapy (HILT)

Home Exercise Program

In addition, all participants were instructed to perform a standardized plantar fascia stretching program twice daily throughout the study period to ensure uniform baseline rehabilitation. Patients were instructed to follow a home exercise program daily for 12 weeks. A calf and arch stretch was taught using a towel: patients were asked to pull the foot back and hold for 30 seconds, repeated 3 times with a 30-second rest interval between the repetitions. The second exercise involved rolling the plantar fascia using a ball or a can for 1 minute, repeated 3 times with a 30-second rest interval between the repetitions. Patients were also instructed to keep the towel and ball or can near the bedside and perform these exercises before going to sleep and prior to taking their first step in the morning.¹⁰

Patients were advised to follow up regularly for the next two months, even after the modalities were applied. The patients were assessed at baseline, 4 weeks, and 12 weeks.

2.5 Outcome Measures

The following outcome measures were used:

Numeric Pain Rating Scale (NPRS) - Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), a common and reliable scale for quantifying subjective pain. Pain was rated on an 11-point scale ranging from 0 (no pain) to 10 (worst possible pain). The NPRS has demonstrated good validity and responsiveness in musculoskeletal conditions and is sensitive to changes over time, making it suitable for evaluating treatment outcomes in plantar fasciopathy.¹¹

Heel Tenderness Index (HTI) - Heel tenderness was evaluated using the Heel Tenderness Index (HTI), which quantifies the degree of pain elicited upon palpation of the plantar fascia at the medial calcaneal tubercle. The HTI is graded on an ordinal scale based on patient response to applied pressure, ranging from no pain to severe pain with withdrawal. This measure provides a simple and clinically relevant assessment of localized tenderness associated with plantar fasciopathy.¹²

Foot and Ankle Outcome Score (FAOS) – This is a patient-reported outcome measure designed to evaluate foot and ankle-related symptoms and functional limitations. The FAOS includes multiple subdomains such as pain, symptoms, activities of daily living, sports function, and quality of life. Scores are normalized on a scale from 0 to 100, with higher scores indicating better function. The FAOS has been validated for use in various foot and ankle conditions, including plantar fasciopathy.¹³

Foot Function Index (FFI) - The Foot Function Index (FFI) was used to assess the impact of foot pathology on pain, disability, and activity limitation. It is a self-reported questionnaire consisting of items grouped into subscales that evaluate pain intensity, functional difficulty, and activity restriction. Scores are expressed as percentages, with higher values indicating greater impairment. The FFI is widely used in clinical research and has demonstrated good reliability and sensitivity in patients with plantar fasciopathy.¹⁴

STATISTICAL ANALYSIS

Data were analyzed using IBM SPSS Statistics. Descriptive statistics were expressed as mean $\pm$ standard deviation (SD). Normality was assessed using the Shapiro–Wilk test. A mixed repeated-measures ANOVA was performed with time (baseline, 4 weeks, 12 weeks) as the within-subject factor and group (ESWT, IASTM, HILT) as the between-subject factor. Main effects of time, group, and time $\times$ group interaction were assessed. Greenhouse–Geisser correction was applied when sphericity was violated. Post hoc comparisons were performed using Bonferroni correction. A p-value < 0.05 was considered statistically significant. Effect sizes were reported using partial eta squared (η^2).

RESULTS

Sixty participants were included in the study and were equally distributed across the three intervention groups: ESWT, IASTM, and HILT ($n = 20$ per group). All participants completed the study, and no dropouts were recorded. The mean age of the study population was 42.6 years, with no statistical difference between all three groups. The majority of the patients were female in all three groups, with the right side being affected the most. Almost all the patients had a long-standing history of standing, even associated with their occupation. All the patients had a gradual onset of pain in the heel, with maximum being in the morning with the first few steps after waking up.

Table 1. Descriptive statistics for all outcome measures

Outcome	Group	Baseline (Mean $\pm$ SD)	4 Weeks (Mean $\pm$ SD)	12 Weeks (Mean $\pm$ SD)
NPRS	ESWT	7.70 $\pm$ 0.95	2.40 $\pm$ 0.84	1.60 $\pm$ 0.70
	IASTM	7.40 $\pm$ 0.84	2.60 $\pm$ 0.97	1.60 $\pm$ 0.70
	HILT	7.40 $\pm$ 0.97	2.30 $\pm$ 0.82	1.90 $\pm$ 0.74
HTI	ESWT	2.60 $\pm$ 0.52	1.00 $\pm$ 0.47	0.60 $\pm$ 0.52
	IASTM	2.60 $\pm$ 0.52	1.10 $\pm$ 0.57	0.70 $\pm$ 0.48
	HILT	2.70 $\pm$ 0.48	1.10 $\pm$ 0.57	0.90 $\pm$ 0.57
FAOS	ESWT	55.10 $\pm$ 2.23	74.30 $\pm$ 2.06	81.80 $\pm$ 2.78
	IASTM	54.70 $\pm$ 2.21	74.80 $\pm$ 1.69	81.20 $\pm$ 2.20
	HILT	56.50 $\pm$ 1.58	76.10 $\pm$ 2.23	78.40 $\pm$ 2.41
FFI	ESWT	63.53 $\pm$ 1.64	36.43 $\pm$ 1.76	21.93 $\pm$ 2.02
	IASTM	63.78 $\pm$ 1.51	36.85 $\pm$ 1.50	21.33 $\pm$ 1.29
	HILT	62.54 $\pm$ 1.42	35.33 $\pm$ 1.73	23.37 $\pm$ 1.26

The baseline characteristics of all three groups were comparable across all outcome measures, with similar mean values observed for NPRS, HTI, FAOS, and FFI. All groups demonstrated substantial improvement over time. For pain (NPRS), mean scores decreased markedly from baseline to 4 weeks and further at 12 weeks in all groups, indicating effective pain reduction. A similar trend was observed for heel tenderness (HTI), with progressive reduction across all time points. Functional outcomes showed consistent improvement, as reflected by increasing FAOS scores and decreasing FFI scores in all groups over time. At 12 weeks, slight variations were observed between groups, with ESWT and IASTM showing comparable improvements, while HILT demonstrated relatively lesser improvement in functional measures. Overall, the descriptive statistics indicate that all three interventions were effective, with gradual and sustained improvement observed across pain, tenderness, and functional outcomes.

Table 2. Mixed Repeated-Measures ANOVA Results

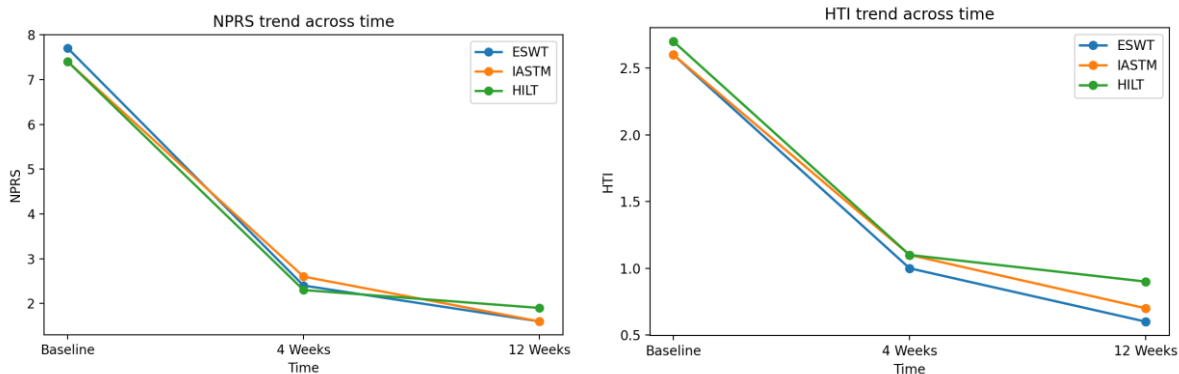
Outcome	Effect	F-value	p-value	Partial η^2
NPRS	Time	442.31	<0.001	0.942
	Group	0.01	0.986	0.001
	Time $\times$ Group	0.61	0.659	0.043
HTI	Time	190.92	<0.001	0.876
	Group	0.43	0.657	0.031
	Time $\times$ Group	0.27	0.893	0.020
FAOS	Time	2001.54	<0.001	0.987
	Group	0.02	0.977	0.002
	Time $\times$ Group	9.67	<0.001	0.417
FFI	Time	5233.40	<0.001	0.995
	Group	0.21	0.815	0.015
	Time $\times$ Group	4.19	0.005	0.237

This table presents the results of the mixed repeated-measures ANOVA, demonstrating a significant main effect of time for all outcome measures, including NPRS, HTI, FAOS, and FFI ($p < 0.001$), indicating substantial improvement across all groups over the study period. There was no significant main effect of group for any outcome ($p > 0.05$), suggesting comparable baseline characteristics and overall treatment effects among the groups. The time $\times$ group interaction was not significant for NPRS and HTI, indicating similar patterns of improvement in pain and heel tenderness across all interventions. However, a significant interaction effect was observed for FAOS ($F = 9.67$, $p < 0.001$, $\eta^2 = 0.417$) and FFI ($F = 4.19$, $p = 0.005$, $\eta^2 = 0.237$), indicating that functional improvement differed between groups over time, with moderate to large effect sizes. Hence, post hoc comparisons were done.

Table 3. Post Hoc Pairwise Comparisons at 12 Weeks

Outcome	Comparison	Mean Difference	p-value	Interpretation
FAOS	ESWT vs HILT	3.40	0.013	ESWT better
	IASTM vs HILT	2.80	0.045	IASTM better
	ESWT vs IASTM	0.60	0.852	No difference
FFI	ESWT vs HILT	-1.44	0.117	No difference
	IASTM vs HILT	-2.04	0.018	IASTM better
	ESWT vs IASTM	0.60	0.670	No difference

This table summarizes the post hoc pairwise comparisons at 12 weeks, highlighting differences in functional outcomes between groups. For FAOS, both ESWT and IASTM demonstrated significantly greater improvement compared to HILT ($p < 0.05$), while no significant difference was observed between ESWT and IASTM. For FFI, IASTM showed a significantly greater reduction in disability compared to HILT ($p = 0.018$), whereas differences between ESWT and HILT and between ESWT and IASTM were not statistically significant. Overall, these findings indicate that although all interventions were effective, ESWT and IASTM were superior to HILT in improving long-term functional outcomes.



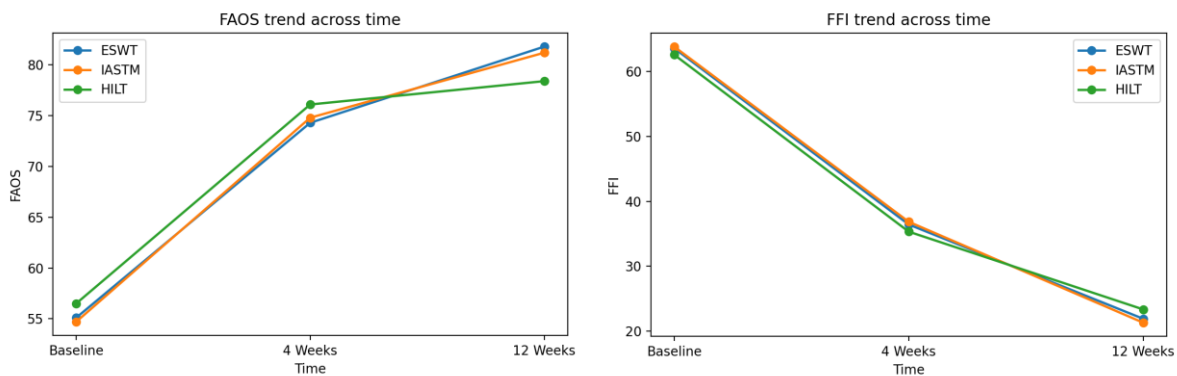


Figure 4 : Trends of all four outcome measures across 12 weeks of time

DISCUSSION

The present study evaluated the comparative effectiveness of extracorporeal shockwave therapy (ESWT), instrument-assisted soft tissue mobilization (IASTM), and high-intensity laser therapy (HILT) in individuals with plantar fasciopathy. The findings demonstrated that all three interventions resulted in significant improvements in pain, heel tenderness, and functional outcomes over time. However, differences between treatment modalities were observed primarily in long-term functional outcomes, with ESWT and IASTM demonstrating superior results compared to HILT.

A significant main effect of time was observed for pain (NPRS), indicating a progressive reduction in pain across all groups throughout the study period. The absence of a significant time $\times$ group interaction suggests that the pattern of pain reduction was comparable among the three interventions. This finding indicates that ESWT, IASTM, and HILT are all effective in modulating pain in plantar fasciopathy, despite differences in their mechanisms of action. ESWT is known to induce analgesia through hyperstimulation and modulation of nociceptive pathways, along with promoting neovascularization.^{4,5} IASTM may reduce pain by improving soft tissue mobility and reducing myofascial restrictions through mechanical stimulation.^{6,7} HILT, on the other hand, exerts its effects via photobiomodulation, enhancing cellular metabolism and reducing inflammatory mediators.^{8,9} The comparable pain outcomes observed in this study suggest that pain relief may be achieved through multiple physiological pathways and may not be sufficient as a standalone parameter for differentiating treatment effectiveness.

Similarly, heel tenderness (HTI) demonstrated a significant main effect of time, with progressive improvement observed across all groups. The lack of a significant time $\times$ group interaction indicates that all three interventions were equally effective in reducing localized tenderness at the plantar fascia insertion. This suggests that improvement in tenderness may be more closely related to general tissue recovery and resolution of local irritability rather than modality-specific mechanisms.

The most notable finding of this study was observed in functional outcomes, as measured by FAOS and FFI. A significant time $\times$ group interaction was identified for both variables, indicating that the magnitude and pattern of functional improvement differed between treatment groups over time. The associated effect sizes were moderate to large, suggesting that these differences were not only statistically significant but also clinically meaningful. Post hoc analysis revealed that both ESWT and IASTM demonstrated significantly greater improvement in functional outcomes compared to HILT at 12 weeks, while no significant difference was observed between ESWT and IASTM.

The superior functional outcomes observed with IASTM may be attributed to its direct mechanical effects on soft tissue remodeling. IASTM applies controlled microtrauma to the affected tissues, which is believed to stimulate fibroblast proliferation, enhance collagen synthesis, and promote realignment of collagen fibers.^{6,7} These effects may improve tissue extensibility and restore the biomechanical properties of the plantar fascia, thereby contributing to improved functional performance. Given that plantar fasciopathy is now widely considered a degenerative rather than inflammatory condition, interventions targeting structural restoration are likely to yield more sustained functional benefits.

ESWT also demonstrated favorable functional outcomes, likely due to its regenerative effects, including stimulation of neovascularization and enhancement of tissue healing processes.^{4,5} However, unlike IASTM, ESWT does not directly influence mechanical tissue remodeling. This may explain the comparable but not superior performance of ESWT relative to IASTM in functional recovery.

HILT, although effective in reducing pain and improving function over time, demonstrated comparatively lesser improvement in long-term functional outcomes. This may be attributed to its primary mechanism of action, which is centered on photobiomodulation and modulation of inflammatory processes rather than structural adaptation of the plantar fascia. While HILT is effective in achieving symptomatic relief, its impact on restoring biomechanical function may be limited when used as a standalone intervention.⁸

The findings of this study are consistent with existing literature, which suggests that ESWT is effective in chronic plantar fasciopathy and that soft tissue mobilization techniques contribute to improved functional outcomes. Previous studies have demonstrated that ESWT promotes tissue regeneration and reduces pain, while manual therapy techniques such as IASTM enhance tissue extensibility and functional recovery. Similarly, laser therapy has been reported to provide short-term pain relief, although its long-term functional benefits appear to be less pronounced.

From a clinical perspective, the results of this study highlight the importance of selecting treatment strategies based not only on pain reduction but also on long-term functional outcomes.¹⁵ While all three modalities can be considered effective for symptom relief, interventions that target structural and biomechanical restoration of the plantar fascia, such as IASTM

and ESWT, may provide greater long-term benefits. HILT may still have a role as an adjunct modality, particularly in the early stages of treatment where pain modulation is a primary goal.

This study has certain limitations that should be acknowledged. The relatively small sample size may limit the generalizability of the findings. Additionally, the follow-up period was limited to 12 weeks, and long-term outcomes beyond this period were not assessed. The absence of a control group also limits the ability to determine the natural progression of the condition and the extent of spontaneous recovery. Future research with larger sample sizes, longer follow-up durations, and inclusion of combined treatment approaches is recommended to further validate these findings.

CONCLUSION

The present study demonstrated that extracorporeal shockwave therapy (ESWT), instrument-assisted soft tissue mobilization (IASTM), and high-intensity laser therapy (HILT) are all effective in reducing pain and heel tenderness in individuals with plantar fasciopathy, as evidenced by a significant improvement over time. However, while pain and tenderness outcomes were comparable across all treatment groups, significant differences were observed in functional outcomes.

IASTM and ESWT demonstrated superior improvement in functional performance and disability reduction at 12 weeks compared to HILT, as reflected by significant time $\times$ group interaction effects for FAOS and FFI. These findings suggest that interventions targeting structural and biomechanical restoration of the plantar fascia may provide greater long-term functional benefits than modalities primarily focused on symptom modulation. From a clinical perspective, treatment selection in plantar fasciopathy should not be based solely on pain relief but should also prioritize restoration of function. IASTM and ESWT may therefore be considered more effective options for achieving sustained functional recovery, while HILT may serve as an adjunct modality for early pain management.

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