Research Article

Effects of Hamstring Flossing on Balance and Foot Function in Female Patients with Plantar Fasciopathy: A Randomized Controlled Study

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Running title: Hamstring flexibility and plantar fasciopathy

Abstract

Background: A relationship between hamstring tightness and plantar fasciopathy (PF) has been reported in the literature. Hamstring flossing has been reported to improve hamstring flexibility; however, its effect on balance and foot function in patients with PF has not been clearly investigated. The aim of this study was to compare the efficacy of a conventional physical therapy treatment protocol combined with hamstring flossing versus conventional physical therapy treatment protocol alone on balance and foot function in patients with PF.

Materials and methods: Thirty patients with PF were randomly assigned into two groups: the study group (A) received hamstring flossing in addition to the conventional physical therapy treatment protocol, whereas patients in the control group (B) received only the conventional physical therapy treatment protocol. Foot function was evaluated by the Foot Function Index (FFI), while the Overall Stability Index (OSI) was assessed by the Biodex Balance System. The outcomes were evaluated at baseline and after three weeks of intervention. The groups were compared using a two-way mixed-design MANOVA test.

Results: Results revealed a significant improvement in the post-test mean values of FFI score and OSI compared with the pre-test values in both the flossing and control groups ($p= 0.001$). No significant differences were observed for both variables post-treatment between the groups ($p>0.05$).

Conclusion: The combination of conventional treatment for PF and hamstring flossing provided no additive benefit compared with conventional treatment alone in patients with plantar fasciopathy.

Keywords: Fasciitis; Plantar; Hamstring flossing; Balance; Foot function

Introduction

Plantar fasciitis (PF) is an overuse syndrome that develops over time. It is most frequently seen in both non-athletic and athletic populations [1]. It affects about 10% of the world's population, at least once in their lifetime, between the ages of 40–60 years [2]. About 80% of all heel pain cases are caused by plantar fasciopathy, with a higher incidence among females [3]. The primary complaint of patients with PF is startup pain—a sharp discomfort at the medial plantar heel during the first steps in the morning or after rest. Although this pain diminishes with walking, it typically worsens by the end of the day or after high-impact activities [4].

Plantar fasciopathy is a multifactorial disorder with several mechanical contributors. The prevailing theory suggests that chronic biomechanical stress triggers microfascial breakdown, impairs healing, and causes abnormal histological responses [5]. Functional deficits such as calf weakness, Achilles tendon/plantar fascia tension, gastrocnemius tightness, poor foot alignment, and hamstring tightness increase strain on the relatively inelastic plantar fascia [6,7]. The incidence of PF is 8.7-fold higher in patients with hamstring tightness[8].

Standard PF management includes patient education [5] and conservative treatments (e.g., stretching, strengthening, ultrasound, heat therapy, medications, and steroid injections) [9]. A key treatment goal is restoring normal tissue flexibility [10], hence plantar fascia, calf, and Achilles stretching are recommended. Despite short-term benefits, many patients report persistent pain post-rehabilitation, underscoring the need for better therapies [11].

Given the link between hamstring tightness and PF, techniques like static stretching and PNF have been used to improve hamstring flexibility [12,13]. However, comparative evidence on these methods is limited. Unlike traditional stretching (which compromises strength), flossing may enhance ROM without reducing power. This technique uses a compressive latex band to temporarily restrict blood flow, followed by exercises to break myofascial adhesions[14].

Despite its potential, the effects of hamstring flossing on balance and function in PF patients remain unstudied. Tissue flossing is emerging for improving ROM, pain, and injury prevention. Kaneda et al. (2020a) [15] found flossing superior to stretching for knee ROM and eccentric strength. However, no studies have examined hamstring flossing's impact on PF-related balance and function (FFI/OSI).

We hypothesized that hamstring flossing would significantly improve FFI and OSI in PF patients. This randomized controlled trial aimed to evaluate hamstring flossing + conventional therapy vs. conventional therapy alone and compare changes in FFI and OSI between groups.

Method

Participants

Thirty patients with PF participated in this study. The patients' mean values of age, body mass, height, and body mass index were 45.93 ± 8.62 years, 85.26 ± 12.92 kg, 159.66 ± 7.02 cm, and 30.35 ± 4.03 kg/m², respectively. They were randomly assigned using a computer-generated method into two equal groups. Patients in the study group (A) received hamstring flossing exercise in addition to the conventional physical therapy treatment program, which included therapeutic ultrasound, moist heat, stretching of the Achilles tendon, stretching of the plantar fascia, and strengthening exercises for the intrinsic foot muscles [16]. Control group (B) patients received only the conventional physical therapy treatment program. All patients read and signed an informed consent form before beginning the study. The study complied with the ethical standards of the Declaration of Helsinki and was approved by the Research Ethical Committee of the Faculty of Physical Therapy, Cairo University (P.T.REC/012/004739). Additionally, the trial was approved by the Pan African Clinical Trial Registry with identification number PACTR202408921930700; the date of registration was 08 August 2024, and it was retrospectively registered.

Study setting and timeline

This study was conducted at the Physical Therapy Outpatient Clinic of the Faculty of Physical Therapy, Cairo University. The practical aspect of this study lasted for sixteen months, starting in October 2021 and ending in January 2023. Inclusion criteria comprised female patients with PF who had limited hamstring muscle flexibility (20° or more loss of knee extension), as measured by the active knee extension test [17]. Participants also had heel pain and tenderness at the medial tubercle of the calcaneus (the site of insertion of the plantar fascia) with a pain intensity greater than 4 out of 10 on the Visual Analog Scale (VAS). Their pain was at its highest level during the first steps in the morning after waking up and during walking after a period of rest. Clinical diagnosis was confirmed using the windlass test; the appearance of pain or increased pain at the insertion of the plantar fascia indicated a positive test for PF[18].

Exclusion criteria

Patients were excluded from the study if they had a history of trauma, strain, sprain, deformity, or radiating pain at the hamstring muscle or the plantar area of the foot within the last six months. Additional exclusion criteria included a body mass index (BMI) greater than 35 kg/m², latex allergy, hypertension, systemic inflammatory disease, or venous thrombotic disease [15, 11].

Instrumentation

1. Biodex Balance System (BBS)

The Overall Stability Index (OSI), a quantitative measure of balance, was assessed using the Biodex Balance System (Biodex Medical Systems, Inc., Shirley, NY). The BBS is a validated and reliable tool for objectively measuring a patient's ability to maintain balance on both stable and unstable surfaces [19]. Higher OSI values indicate poorer balance performance.

2. Sphygmomanometer

Floss band compression during treatment was monitored using a modified sphygmomanometer [20], which operates on the same principles as the Kikuhime pressure sensor [21].

3. Voodoo Flossing Band

A Sanctband COMPRE Floss Blueberry band (5.1 cm × 3.5 m; Sanct Japan Co., Ltd.) was used for hamstring flexibility training. The flossing protocol involved wrapping the latex band around the target tissue for 1–3 minutes [14], maintaining an interface pressure of 140–160 mmHg (measured by sphygmomanometer), and guiding the patient to move the flossed joint through its end-range motion [18].

Procedures

The study consisted of four phases: initial assessment phase, treatment phase, re-assessment phase, and statistical analysis.

Initial assessment phase

This study used a pre-test post-test control group design, in which two groups of patients were tested before and after treatment. Balance and foot function were assessed for each patient in both groups.

Balance testing via biodex balance system

The platform of the BBS was set at firmness level eight, the most stable setting. Each patient stood barefoot on the platform with hands beside the body while maintaining a comfortable position. The BBS screen was adjusted to eye level according to each patient's height, and handrails were positioned for safety in case of balance loss. The test began when patients were informed that "the plate is now unlocked." With eyes open, patients were instructed to keep the platform level by centering the cursor on the bull's-eye of the screen. The test duration was preset to 20 seconds. After completion, the platform locked automatically, and results were averaged by the software. The Overall Stability Index (OSI) was recorded as the mean of three trials.

Foot function index

The FFI measured the impact of foot pathology on function in terms of pain, disability, and activity restriction. Patients in both groups were tested before and after three weeks of intervention. Each patient scored questions on a 0–10 scale (0 = no pain/difficulty; 10 = worst pain/difficulty). Subscale scores were calculated by dividing the total score by the maximum possible score and multiplying by 100. Scores range from 0% (no impairment) to 100% (maximum impairment) [22].

Treatment Phase

Hamstring flossing band procedures

A Voodoo floss band (2 m × 5 cm; Mobility WOD) was applied to the hamstring muscle of the affected leg three times weekly for three weeks [15]. Patients stood with the affected foot forward while the examiner wrapped the band from distal to proximal over the distal third of the thigh, between the anterior superior iliac spine and patella, with each wrap overlapping half of the previous one. The therapist then performed four passive twists of the wrapped band before guiding the patient through two minutes of active knee flexion/extension (to maximum range of motion). This was followed by a one-minute rest and repetition of the exercise. Finally, the band was removed, and patients walked for one minute to restore circulation [21].

Despite the general safety of flossing, several precautions were implemented: Patients were instructed to report any strong tingling or pain during application, which would require immediate band removal. Skin color was checked post-removal by applying and releasing finger pressure to verify normal capillary refill. Application duration was adjusted (2–5 minutes) based on individual tolerance [23]. All participants were advised to maintain their regular activity levels and avoid additional training programs.

Conventional physical therapy protocol

Therapeutic ultrasound (continuous mode: 1.5 W/cm², 3 MHz) was applied for seven minutes at the most painful plantar site three times weekly for three weeks [16]. For Achilles tendon stretching, patients faced a wall with hands supported, aligned the affected leg behind the non-affected leg, and bent the front knee while keeping the back knee straight to feel a calf/Achilles stretch. This 10-second hold was repeated 15 times twice daily for three weeks (performed both in-clinic and at home). Plantar fascia stretching involved sitting with the affected leg crossed and pulling the toes toward the shin until a stretch was felt in the arch (20-second hold, 15 repetitions twice daily). Intrinsic foot muscle strengthening ("towel toe curls") required patients to grasp a towel with their toes (3-second hold, 100 repetitions daily). Additionally, patients submerged the affected foot in warm water for 20 minutes nightly.

Re-assessment phase

After three weeks of treatment, all patients underwent reassessment of OSI and FFI scores.

Statistical analysis

Two independent variables were examined: group (flossing + conventional therapy vs. conventional therapy alone) and time (pre- vs. post-treatment), with FFI and OSI as dependent variables. Sample size was calculated using G*Power (v3.1.9.6) assuming a medium effect size (Cohen's d = 0.50) and 80% power. Of 45 initially recruited patients, 30 completed the study (33% overall dropout rate; 21% after enrollment). Normality was confirmed via Kolmogorov-Smirnov/Shapiro-Wilk tests and distribution analysis. Parametric tests included unpaired t-tests (demographics), chi-square tests (affected-side distribution), Levene's test (homogeneity), and two-way mixed-design MANOVA (FFI/OSI comparisons). Analyses used SPSS v25 (IBM), with significance at $p < 0.05$.

Results

Flow chart of participants

Of 45 patients who initially met the inclusion criteria, seven declined participation. The remaining 38 patients were randomly allocated into two equal groups. Five patients withdrew after initial evaluation due to work commitments (three from Group A and two from Group B). Two Group B participants dropped out after three weeks due to personal reasons, and one Group A patient was excluded during analysis. Consequently, 30 female patients with unilateral plantar fasciopathy completed the study (Figure 1).

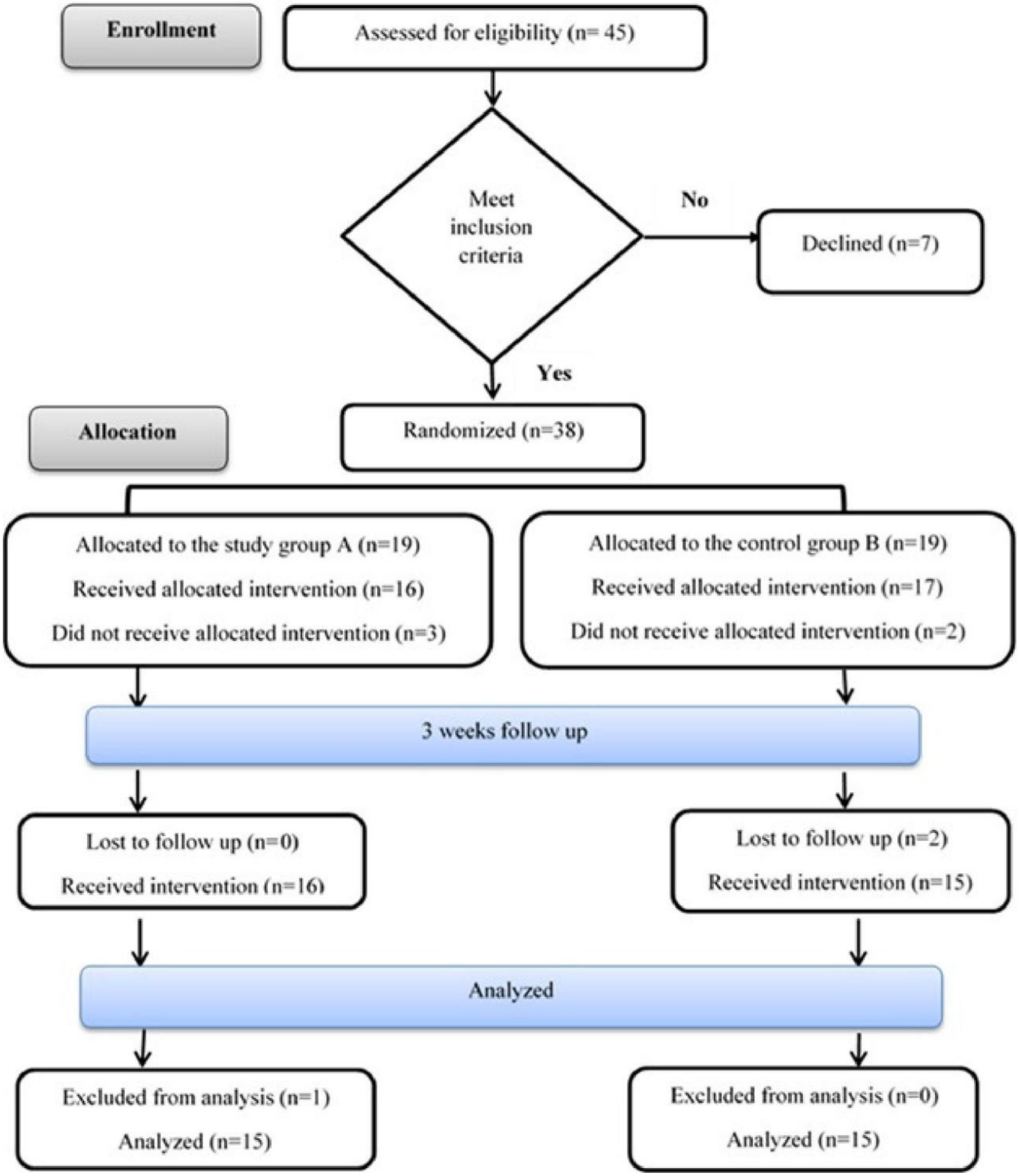

Figure 1: Participants, Flow Chart

Patients' demographic data

Unpaired t-tests and chi-square tests showed no significant differences between groups for age, weight, height, BMI, or affected side distribution ($p > 0.05$) (Table 1)

Table 1. Comparisons of patients' characteristics between the study and control groups

Patients' characteristics		Study group $\bar{x} \pm SD$	Control group $\bar{x} \pm SD$	t-value	p-value
Age (years)		47.2 ± 9.7	44.9 ± 9.5	0.67	0.51
Weight (Kg)		82.4 ± 13.8	84.1 ± 15.9	-0.32	0.75
Height (cm)		159.4 ± 7.7	157.1 ± 8.1	0.81	0.42
BMI (Kg/m^2)		30.35 ± 4.03	30.35 ± 4.03	-0.89	0.37
(%) affected side, n	Right side	(44%) 7	(47%) 7	(χ^2 = 0.02)	0.87
	Left side	(56%) 9	(53%) 8		

$\bar{x} \pm$ SD: mean ±standard deviation
χ^2: Chi squared value

Effect of treatment on FFI and OSI

Mixed-design MANOVA revealed significant reductions in FFI scores post-treatment compared to baseline in both groups ($p < 0.001$) (Figure 2). Similarly, OSI values decreased significantly post-treatment ($p < 0.001$) (Figure 3). Between-group comparisons showed no significant differences in pretreatment or post-treatment values for either FFI or OSI ($p > 0.05$) (Table 2).

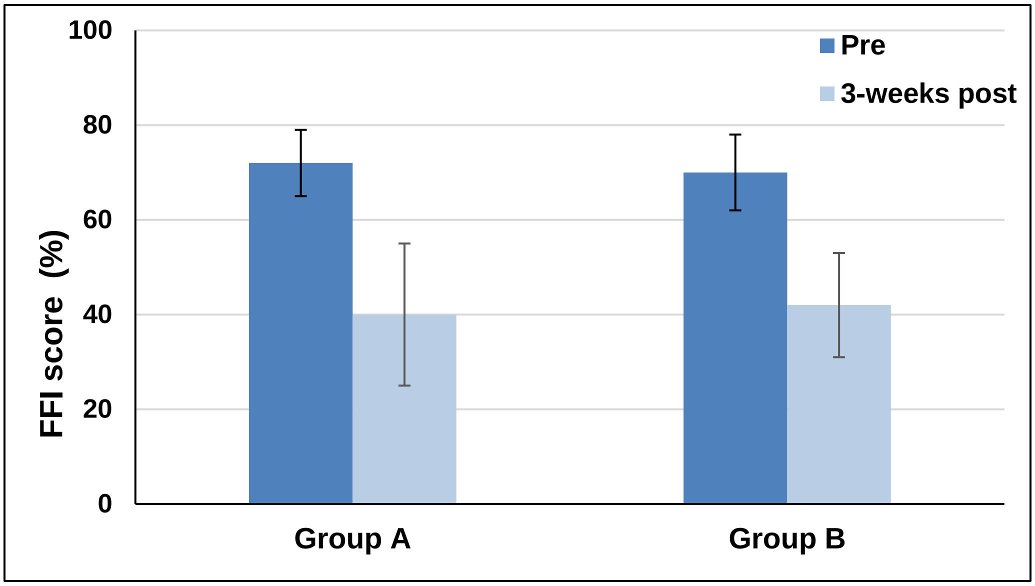

Figure 2: Mean values of the FFI score pre, and 3 weeks post-treatment for patients in the both tested groups.

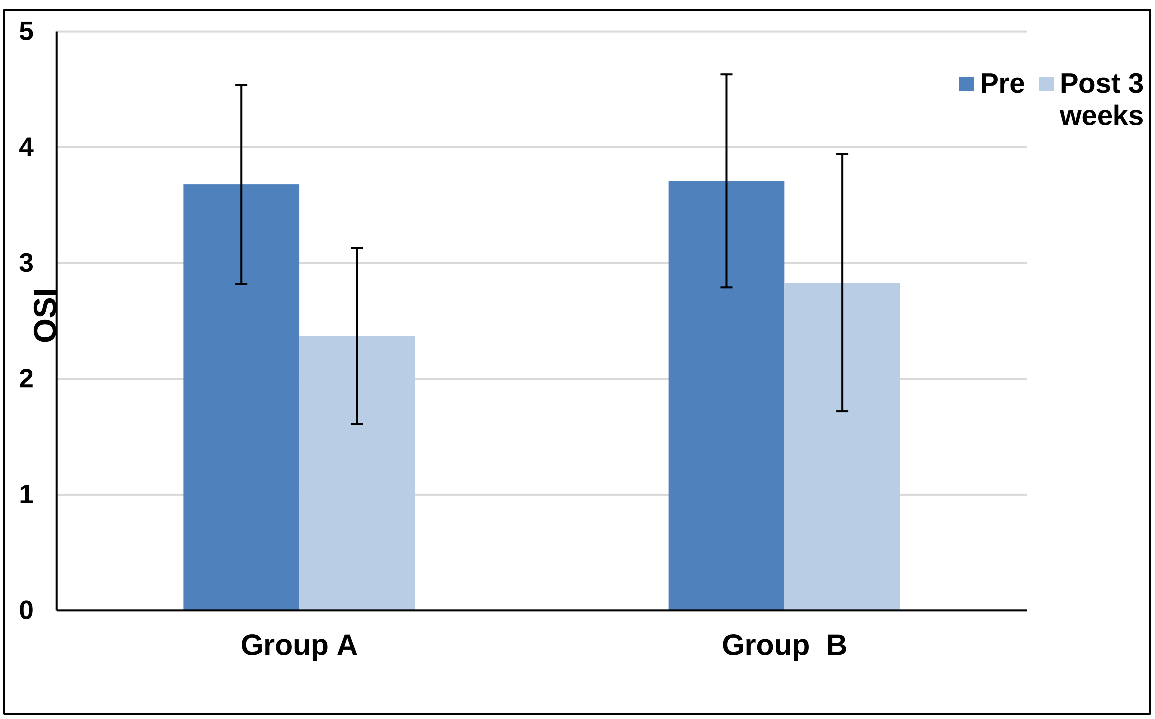

Figure 3: Mean values of the OSI of balance pre, and 3 weeks post-treatment for patients in the both tested groups.

Table2. Mean FFI and OSI pre and post treatment of study and control groups

	Group A	Group B			
	Mean ± SD	**Mean ± SD**	**MD**	**p-value**	**Effect size**
FFI					
Pretreatment	0.72 ± 0.07	0.70 ± 0.08	0.02	0.57	
Posttreatment	0.40 ± 0.15	0.42 ± 0.11	-0.02	0.67	0.15
MD	0.32	0.28			
% of change	44.44	40			
	P = 0.001	*P = 0.001*			
OSI					
Pretreatment	3.68 ± 0.86	3.71 ± 0.92	-0.03	0.92	
Posttreatment	2.73 ± 0.76	2.83 ± 1.11	-0.46	0.18	0.48
MD	1.31	0.88			
% of change	35.60	23.72			
	P = 0.001	*P = 0.001*			

SD, standard deviation; MD, mean difference; p-value, probability value

Discussion

Within-subject effects (conventional treatment with hamstring flossing)

This study investigated the effects of adding hamstring flossing to conventional physical therapy on FFI and OSI in 30 female patients with plantar fasciopathy. The significant post-treatment improvements in both groups may be attributed to Achilles tendon and plantar fascia stretching, which target calf muscle tightness—a key contributor to plantar fasciopathy [26]. Stretching these structures remains a cornerstone of treatment [27], with Engkananuwat et al. (2018) [28] demonstrating that combined Achilles tendon and plantar fascia stretching improves pain and ankle dorsiflexion ROM more effectively than isolated Achilles stretching.

Stretching enhances joint ROM and balance [29], while plantar fascia-specific stretching is critical for arch stability via the windlass mechanism. Restricted ankle dorsiflexion due to Achilles tightness forces compensatory subtalar motion, increasing stress on the plantar fascia and promoting overpronation—a pathway to fasciopathy and flatfoot [30].

In the current study, the improvement in foot function observed in both groups may be linked to the combined effects of therapeutic ultrasound and moist heat application. Therapeutic ultrasound has been shown to stimulate the healing process [11], while moist heat significantly improves local circulation and reduces plantar fascia pain [31]. Sullivan et al. (2015) [32] highlighted that weakness in intrinsic and extrinsic foot muscles may contribute to symptom recurrence in PF patients due to impaired muscle function and joint positioning during gait. Consequently, strengthening intrinsic foot muscles represents a crucial factor for counteracting excessive stresses on the plantar fascia [24]. Supporting this, Wei et al. (2022) [33] reported that intrinsic foot muscle training enhances biomechanical function of the medial longitudinal arch and improves dynamic postural balance. The intrinsic foot muscle strengthening protocol implemented in this study likely contributed to the observed heel pain improvement.

The significant post-treatment reduction in OSI and FFI scores in the flossing group may reflect improved hamstring flexibility achieved through flossing band application. Behm et al. (2019) [34] demonstrated that flossing bands generate compressive stress on target muscles, skin, and fascia, modifying fluid viscosity and reducing movement resistance. Similarly, Kaneda et al. (2020) [15] found that flossing induces blood flow restriction and localized vascular occlusion, which alters fascial-neuromuscular interactions to facilitate greater fascial mobility. Notably, Kaneda et al. (2020) [15] further established that hamstring flossing surpasses dynamic stretching in improving hamstring flexibility in healthy young males.

Between subject effect

The current study found no statistically significant differences in OSI and FFI between the control and experimental groups. This may be explained by the conventional treatment program's inclusion of gastrocnemius muscle stretching, which could have indirectly improved hamstring flexibility [35]—the primary target of hamstring flossing.

Myers (2009) [36] conceptualized the superficial back line as a myofascial chain connecting the hamstrings proximally to the gastrocnemius and plantar fascia distally. This anatomical relationship suggests that hamstring flexibility enhances calf muscle stretching efficacy, thereby improving foot pain and function. Fauris et al. (2021) [37] supported this, demonstrating that flexibility training on any segment of this chain increases hamstring and calf flexibility while improving ankle dorsiflexion range. Although hamstring flexibility training may benefit plantar fasciopathy treatment, targeted interventions for the plantar fascia remain equally impactful [38], potentially explaining the comparable outcomes between groups.

Gastrocnemius shortening often manifests as calf pain before hamstring tightness, limiting hamstring flexibility testing due to gastrocnemius-related discomfort [39]. Russell et al. (2010) [35] investigated this dynamic, comparing hamstrings-only, gastrocnemius-only, and combined stretching. Their results—aligning with our findings—highlighted the unique role of gastrocnemius stretching in improving knee extensibility, likely due to its biarticular anatomy spanning the knee and ankle

Contrasting opinions

Contrary to our findings, Radford et al. (2007) [40] reported that two weeks of calf muscle stretching failed to significantly improve first-step pain, foot pain, or foot function in 92 plantar fasciitis patients compared to a non-stretching control. This discrepancy may stem from methodological differences: Radford et al. (2007) [40] used a wedge-based stretching protocol, which redistributed pressure to the plantar heel, potentially exacerbating discomfort. In contrast, our study employed dynamic lunge stretches for the Achilles tendon—a method associated with improved muscle strength [41]. The strength gains from dynamic stretching may have enhanced extrinsic foot muscle function, compensating for the impaired arch stabilization and reduced ground reaction force absorption characteristic of PF [42].

Our results align with Wu et al. (2022) [43], who demonstrated that hamstring flossing enhanced knee ROM without compromising static balance in healthy women. This supports the premise that flossing improves flexibility without negatively affecting postural control—a critical consideration for PF rehabilitation.

Study limitations

- Lack of a non-intervention control group, which limits our ability to assess spontaneous symptom progression.
- Variable flossing band pressure due to subjective discomfort and application technique differences.
- Limited generalizability beyond the studied age group and gender (female patients aged 40–60 years).
- Exclusion of balance training, whose potential effects on functional improvement remain unexplored.
- Short intervention duration (3 weeks), which may not capture long-term outcomes.

Future directions

- Placebo-controlled trials to isolate the effects of hamstring flossing.
- Inclusion of a non-intervention group to benchmark natural symptom progression.
- Integration of neuromuscular training for ankle/foot muscles and long-term follow-up.
- Investigation of balance training as an adjunct therapy for plantar fasciopathy.

Conclusion

The addition of hamstring flossing to conventional physical therapy did not significantly enhance foot function or balance in patients with plantar fasciopathy compared to conventional treatment alone.

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Authors' contributions

Conceptualization and supervision : Amal Abdelrahman Elborady; Yassmin Essam Mohamed
Methodology: Eman Ahmed Ahmed ; Nagui Sobhi Nassif; Rafik Elmaamoon Radwan
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Conflict of interest

The authors declared no conflict of interest.

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