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 relation between hamstring tightness and Plantar Fasciopathy (PF) has been reported in the literature. Hamstring flossing was reported to improve hamstring flexibility, however its effect on balance and foot function in patients with PF was not clearly investigated. The aim of this study was to compare the efficacy of conventional physical therapy treatment protocol plus hamstring flossing with 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 study group (A) patients received hamstring flossing in addition to the conventional physical therapy treatment protocol, whereas patients in control group (B) received only the conventional physical therapy treatment protocol. Foot function was evaluated by Foot Function Index (FFI), while Overall Stability Index (OSI) was assessed by the Biodex Balance system. The outcomes were evaluated

at the baseline and after three weeks of intervention. The groups were compared using the two-way mixed design MANOVA test.
Results: Results revealed a significant improvement in the post testing mean values of FFI score and OSI compared with the pre testing ones in flossing and control groups ($p = 0.001$). No significant differences for both variables post-treatment between both groups were found ($P>0.05$).
Conclusion: The combination of conventional treatment of PF and hamstring flossing had no additive gain compared with conventional treatment only for managing patients with plantar fasciopathy
Keywords: Fasciitis, Plantar, Hamstring Flossing, Balance, Foot Function

Introduction

Plantar Fasciitis (PF) is an overuse syndrome as it develops over time. It is most frequently seen in both the non-athletic and athletic populations [1] (cited from journal of modern rehabilitation). It affects about 10% of the world's population, at least once in their life, between the ages 40-60 years [2]. About 80% of all heel pain cases are caused by plantar fasciopathy, with greater incidence among females [3]. The main complaint of patients with PF is 'start-up pain' which is a severe discomfort, at the medial portion of the plantar aspect of the heel, on the first walking steps at morning and after a period of rest. Although this severe discomfort improves after walking for a time, yet, it usually worsens at the end of the day and after engaging in high-impact sports and activities [4].
Plantar fasciopathy is a multifactorial disorder caused by several linked mechanical causes. The most frequently accepted viewpoint is that chronic biomechanical stressors can stimulate microfascial breakdown, inhibit the normal healing process, and lead to abnormal histological responses [5]. Functional biomechanical deficits such as calf muscle weakness, achilles tendon and plantar fascia tension, gastrocnemius tightness, inappropriate foot alignment and hamstring tightness increase tension on the plantar fascia, which is known to have low elasticity [6,7]. The incidence of PF in patients with hamstring tightness is 8.7 times higher than that in patients without hamstring tightness [8]. The main lines of treatment for plantar fasciopathy are patient education [5], and conservative treatment that includes stretching, strengthening, ultrasound, heating, medication and steroid injections [9]. One of the essential targets of the overall therapy plan is regaining the affected tissues' normal flexibility [10]. Therefore, stretching of the plantar fascia, calf muscle and achilles tendon is suggested for treatment of PF. Despite the reported positive short-term treatment outcomes of the previously stated treatment methods yet, most of the patients who completed their rehabilitation for PF still report pain. This highlights the need for more effective management plans to be identified [11].
Because of the importance of addressing hamstring tightness when treating patients with PF, several researchers used different techniques to improve flexibility of the hamstrings such as static stretching and Proprioceptive Neuro-Muscular Facilitation (PNF) stretching [12,13]. A comparison between the effects of various types of flexibility is still largely missing. Instead of using these traditional stretching techniques, which increase flexibility but deplete strength, flossing is hypothesized to increase ROM while potentially leaving power unaltered. Tissue flossing involves wrapping a specialized latex band around a muscle group and providing compression, that partially occludes blood flow, followed by performing exercises. This is hypothesized to improve flexibility by dissipating myofascial adhesions [14]. The biomechanical effects of hamstring flexibility training on balance in patients with PF have not been fully addressed. Additionally, the effect of using a new modality for improving hamstring flexibility on balance and function in patients with

PF has never been studied before. Tissue flossing is a new method aiming to improve Range of Motin (ROM), pain, and enhancing injury prevention. According to Kaneda et al. (2020 a [15]), flossing had a better impact than stretching on knee Range of Motin (ROM) and maximum eccentric knee extension. But Up to the knowledge of the author, the exact effect of hamstring flossing on balance and foot function in patients with PF needed to be investigated. Our hypothesis was that there is a significant effect of hamstring flossing on the FFI score and OSI in patients with PF. We conducted a randomised conventional -controlled trial to determine whether hamstring flossing is an effective treatment for plantar fasciopathy. Therefore, the aim of the present study is to investigate the effects of using hamstring flossing technique and the conventional physical therapy treatment on foot function index and balance in patients with plantar fasciopathy then compare the changes that may occur in both variables between both examined groups.

Methods

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 by using a computer-generated method into two equal groups. Patients in study group (A) received hamstring flossing exercise in addition to the conventional physical therapy treatment program (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 the conventional physical therapy treatment program only. All patients read and signed an informed consent form before initiation of 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 from Pan African Clinical Trial Registry with identification number PACTR202408921930700, date of registration was 08 August 2024 and it was retrospectively registered.

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 October 2021 till January 2023. Inclusion criteria comprised: female patients with PF had limited hamstring muscle flexibility (20°, or more, loss of knee extension) that was measured by active knee extension test [17]. Heel pain and tenderness at the medial tubercle of the calcaneus (site of insertion of the plantar fascia) > 4 out of 10 on the Visual Analog Scale (VAS) and their pain was at its highest level during the first steps in the morning, after waking up and during walking after a period of resting. Clinical diagnosis was carried out using the windlass test, Appearance of pain or increased pain level at the insertion of the plantar fascia indicates a positive test for PF [18].

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. Patients were also excluded if they had a body mass index (BMI) greater than 35 kg/m², and if any of them is suffering from latex allergy, hypertension, systemic inflammatory disease or venous thrombotic disease [15,11].

Instrumentation

1. Biodex Balance System (BBS)

The overall stability index (OSI), which is an indicator for balance assessment, was measured using the Biodex Balance System (BBS) (Biodex medical systems, Inc. Shirley NY). The BBS

provides a valid and reliable objective measure of the patient's ability to balance on stable and unstable surfaces [19]. A high OSI score indicates poor balance.

2. Sphygmomanometer

The compression of the floss band during treatment was monitored with an adapted sphygmomanometer [20]. It works along with the same principles as the Kikuhime pressure sensor [21].

3. Voodoo Flossing Band

Voodoo flossing band (Sanctband COMPRE Floss Blueberry; 5.1 cm × 3.5 m; Sanct Japan Co., Ltd.) was used while performing the hamstring flexibility training. Flossing treatment consists of wrapping a latex rubber band around the target tissue for about 1–3 min [14]. The interface pressure between the skin and the floss band was measured by a sphygmomanometer with a mean value range between 140 to 160 mmHg. Subsequently, the patient was asked to move the joint of the flossed region to the end-range position [18].

Procedures

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

A. Initial assessment phase

This study's design is 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 the two tested groups.

1. Balance testing via Biodex Balance System

2. The platform of the BBS was set at firmness level eight, which is the most stable level. Each patient was asked to stand barefooted on the platform, place both hands beside the body, trying to attain the most comfortable position. According to the height of each patient, the BBS screen was adjusted to the eye level. The handrails were accommodated to each patient's hand height in a way that allowed safety in case of balance loss. The test started when the patient was informed that "the plate is now unlocked". With the eyes opened, the patient was instructed to keep the platform levelled by making the panel cursor at the center of the bull's eye of the screen. The test time is preset by the device to 20 seconds. Once the patient completed the test, the foot platform locked automatically, and the test trial was ended. The results were collected and averaged by the software and displayed on the screen. The overall stability index (OSI) was the variable of choice and the mean of three trials was recorded.

Foot Function Index (FFI)

FFI was used to measure 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 was asked to score each question on a numerical pain rating scale from 0 (no pain or difficulty) to 10 (worst pain or so difficult). Each sub-scale score was recorded and the total score of all answers was divided by the maximum score and multiplied by 100. The minimum score is 0%, indicating no pain or difficulty, while higher FFI scores indicate poor foot health with a maximum score 100% indicating worst pain and extreme difficulty (requiring assistance) [22].

Treatment phase

1. Hamstring flossing band procedures

A voodoo floss band (2 m * 5 cm, mobility WOD) was applied by the examiner on hamstring muscle of the affected leg three times per week for three successive weeks as per [15], the patient was asked to stand with the foot of the affected leg stepped forward. Floss band was wrapped above the distal third of the thigh, between the anterior superior iliac spine and the patella from distal to proximal making each wrap overlying half of the previous one. Afterwards, the therapist performed passive twisting of the wrapped part of the band at the lower thigh four times. followed by performing two minutes of active repeated knee flexion and extension motion (to her maximum permissible Range of Motin (ROM). This motion was performed for two minutes, followed by a one-minute rest, then repeated once again. Finally, the floss band was removed, and the patient was instructed to walk around for one minute to allow for blood flow to return to the leg [21].

Although the use of the flossing band is apparently safe, it is essential to consider several factors, such as the potential influence of the material type and the resistance of the patient to the applied pressure during bandaging. Therefore, continuous monitoring of the patient is critical to ensure that excessive pressure is not being applied. This was achieved first by asking the patient prior to initiation of treatment to inform the examiner of strong tingling or pain that may be felt during application of the floss band, where in such case the band must be immediately removed. Second, the patient's skin color was examined after removing the flossing band by applying pressure with the fingers then remove this pressure and observe if the skin color returns to normal. Finally, the duration of application of the band varied between two and five minutes, depending on the patient's tolerance [23]. Participants in both groups were advised not to alter their usual activity nor to participate in additional training programs beyond those of the intervention.

2. Conventional physical therapy protocol for plantar fasciopathy [16].

- Therapeutic Ultrasound (US)

Continuous mode ultrasound with an output of 1.5w/cm2 and frequency 3MHz was applied for 7 minutes at the most painful point at the sole of the foot, just distal to the calcaneus, at the mid-foot region, once a day, three days per week, for three successive weeks [16]. Therapeutic US creating an analgesic effect and hence, reduction of pain will take place [11].

Achilles tendon stretching protocol

Every patient was asked to stand facing the wall with both hands supported on the wall in front of her. The second toe and the calcaneus of the affected foot were aligned in the sagittal plane. The patient was then instructed to place and align the affected leg behind the non-affected leg and to bend the knee of the non-affected leg while keeping the knee of affected leg straight until she feels stretch at the calf muscle and the Achilles tendon area, keeping the heel resting firmly on the floor. This position was maintained for 10 seconds and repeated for 15 times twice per day, five days per week for three successive weeks (patients performed it during the sessions and as a home program).

- Stretching of the Plantar fascia

All patients in both groups performed self-stretch for the plantar fascia [16]. This was done by asking the patient to sit comfortably, cross the affected leg over the other leg, then pull the toes of the affected foot backwards towards the shin, using the hand on the affected side, until a stretch was felt at the arch of the foot. Stretch was maintained for 20 seconds followed by a 20 second rest. A total of 15 repetitions were done. The stretching program was performed twice a day, five days per week for three successive weeks (patients performed it during the sessions and as a home program).

- Strengthening exercises for the intrinsic foot muscles (Towel toe curls)

Each patient was asked to sit on a chair with suitable height so that the hips and knees are bent to 90 degrees. A towel was placed under the patient's affected foot and the patient was asked to draw the towel beneath her foot by flexing the toes then hold this grasp for three seconds. This exercise was performed 100 repetitions per day, every day for three successive weeks (patients performed it during the sessions and as a home program) [24].

- Moist heat

Every patient was asked to submerge the affected foot in a warm water bath for 20 min at night every day.

C. Re-assessment phase

After three weeks of treatment, the OSI and FFI were re-assessed for all patients in the two tested groups.

D. Statistical analysis

This study included two independent variables. The first independent variable was the tested group (between subject factors) with two levels: hamstring flossing together with the conventional physical therapy program and the conventional physical therapy program alone. The second independent variable was the time of testing (within subject factor) with two levels: Pre-treatment and 3-weeks post-treatment. Two dependent variables were measured. They were the FFI score and the OSI in patients with plantar fasciopathy.

Regarding sample size calculation, most commonly, a study's effect size is calculated as Cohen's d. small, medium or large effect size corresponding to Cohen's values of 0.20, 0.50, and 0.80, respectively [25]. Accordingly, a medium effect size of 0.50 was used to calculate the sample size for the current study, using the G*power software, version 3.1.9.6. to compensate for any potential dropout, 45 patients were recruited to participate in the study. The percentage of dropout of patients was 33 percent (This drop out ration based on including candidates who declined to participate in the current study). However, if we considered only the pariticapants who participated in this study and dropped out later they are 8 out of total 38 is 21 percent. Thus a total of 30 patients participated and completed the study, fulfilling an effect size of 0.5 and a power level of 0.80. Prior to final statistical analysis, data were screened for normality assumption by assessing the normality tests; Kolmogorov-Smirnov and Shapiro-Wilks tests. In addition, the distribution curves were explored for skewness and kurtosis. Since the normality and homogeneity of variance assumptions were met, parametric statistical analysis of the collected data was done.

Unpaired t-test was conducted to compare patients' demographic data between groups, whereas Chi-squared test was used to compare the distribution of the affected side between groups. At the same instance, Levene's test was carried out to ensure the homogeneity between groups. Two-way mixed design Multivariate Analysis of Variance (MANOVA) was used to compare between the mean values of the FFI and the OSI between groups, before and after training. The level of significance for all statistical tests was set at 0.05. All statistical analyses were performed through the Statistical Package for Social Science (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Results

Flow chart of participants

Of 45 patients who initially met the inclusion criteria, seven refused to participate in the study.

The remaining 38 patients were randomly assigned into two equal groups. Of these 38 patients, five patients withdrew from the study after their initial evaluation because of problems in their work. Three of them were from group A and two were from group B. Additionally, two patients from group B dropped out after 3 weeks of treatment as they were unable to follow up with the study due to personal issues. Finally, one patient from group A was excluded from the study at the analysis phase. Therefore, 30 female patients with unilateral plantar fasciopathy participated in and completed this study. Figure 1 shows the CONSORT flow chart of the study.

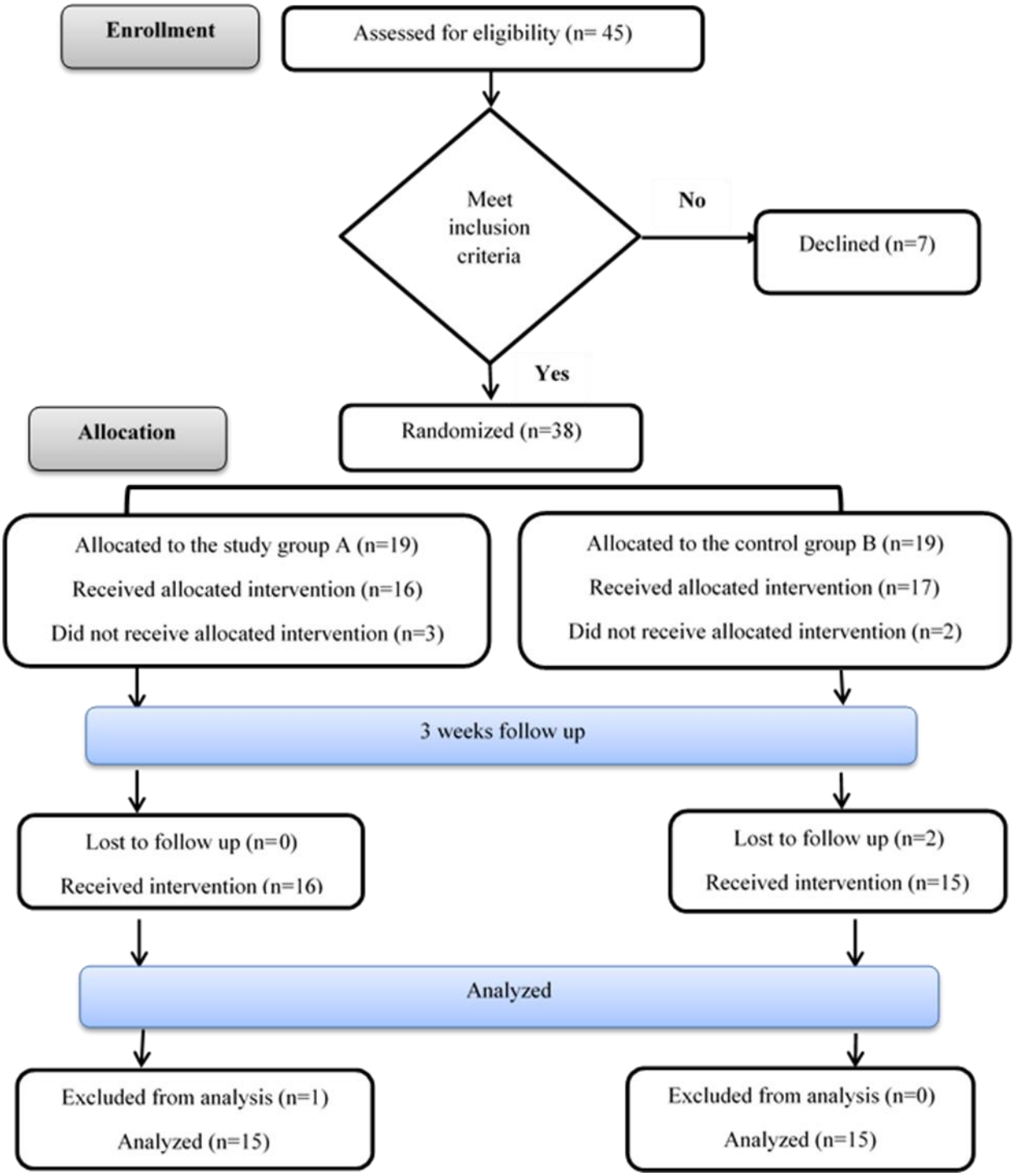

Figure 1: Participants, Flow Chart

Patients 'Demographic data

Unpaired t-test and Chi squared test revealed that there was a non-significant difference between both groups for mean 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 kg/m^2	30.35 ± 4.03 kg/m^2	-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 that the mean values of the FFI score were observed to decline in three weeks post-treatment as compared to the pretreatment values in patients of the two tested groups ($p < 0.001$). The reported values of FFI score pre, and 3-week post-treatment for both the study and control groups are presented in figure (2). Additionally, there was a significant decrease in the post-treatment mean values of the OSI as compared to the pre-treatment values for both the study and control groups ($p < 0.001$). The mean values of the OSI in the two tested groups pre, and 3-weeks post-treatment are presented in figure (3). For the between group comparisons, it was shown that there was no significant difference for the pre-treatment mean values of both dependent variables between both groups ($p > 0.05$). Likely, the post-treatment mean values of both dependent variables were also non-significant between both groups ($p > 0.05$) (Table 2).

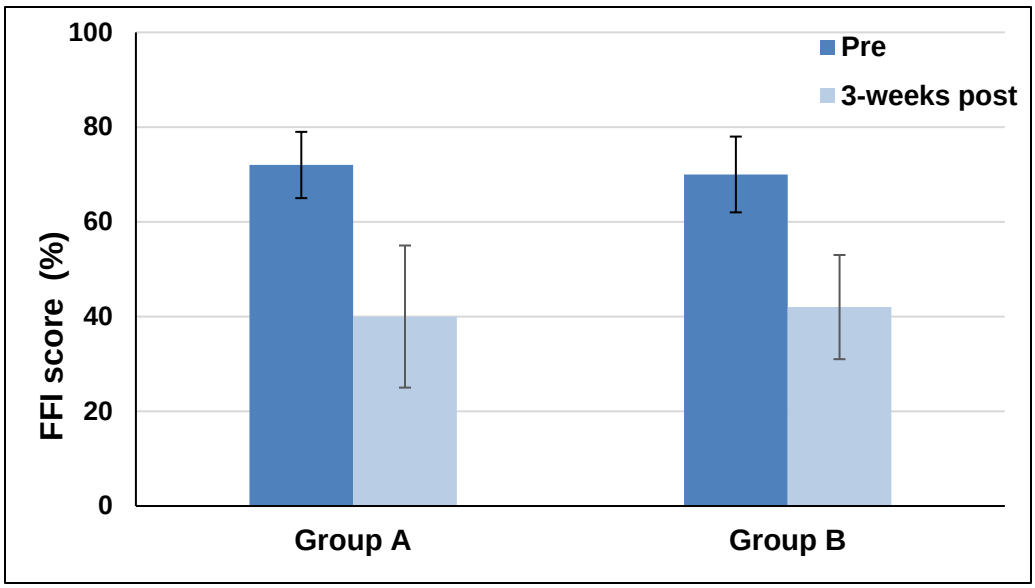

Figure 2: Mean values of the FFI score pre, and 3 weeks post-treatment for patients in the both tested groups.

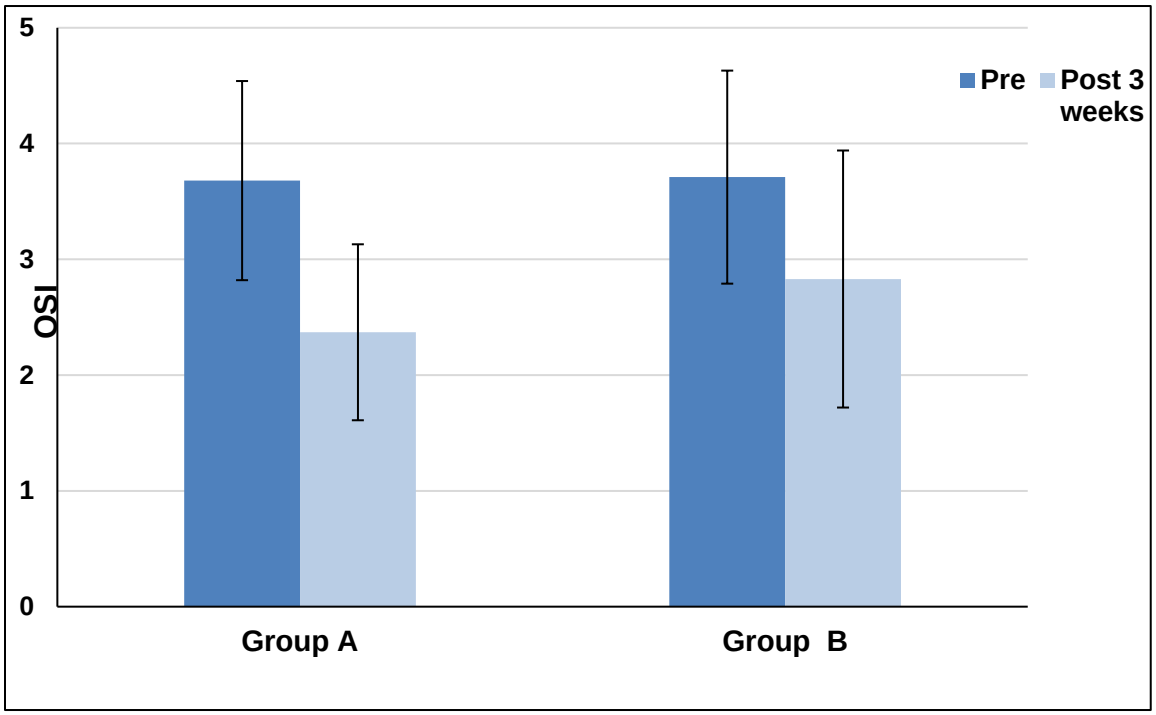

Figure 3: Mean values of the OSI of balance pre, and 3 weeks post-treatment for patients in the both tested groups.

Table 2. 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					
Pre treatment	0.72 ± 0.07	0.70 ± 0.08	0.02	0.57	
Post treatment	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					
Pre treatment	3.68 ± 0.86	3.71 ± 0.92	-0.03	0.92	
Post treatment	2.37 ± 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 effect (conventional treatment and adding hamstring flossing)

The current study was carried out to investigate the effects of adding hamstring flossing to the conventional physical therapy treatment program on the FFI and the OSI of balance in 30 female patients with plantar fasciopathy. Two-way mixed design MANOVA revealed that there was a significant decrease in the FFI and the OSI post-treatment as compared to the pre-treatment variables in patients of both groups. This may be attributed to the effect of Achilles tendon and plantar fascia stretching which were introduced in the treatment of both groups. As tightness of the calf muscles and/or Achilles tendon is considered as one of the most common causes of plantar fasciopathy [26]. thus, stretching of the gastrocnemius, soleus and plantar fascia remains a keystone in the treatment of plantar fasciopathy [27] Engkananuwat et al., 2018 [28]. stated that simultaneous stretching of the Achilles tendon and plantar fascia provide a double improvement for pain and ankle dorsiflexion Range of Motin (ROM) than stretching of the Achilles tendon alone.

Stretching is commonly utilized to elongate muscles and increase the ROM around the joint and is theorized to improve balance performance [29]. Stretching of the plantar fascia plays a vital role in the treatment of PF and adherence to a daily routine of plantar fascia stretch is the key to successful treatment [27]. The plantar fascia is responsible for maintaining plantar arch stability and height during gait via the windlass mechanism. During the late stance of gait, a tight Achilles tendon restricts ankle dorsiflexion, thus hindering body forward progression. Compensation for

this issue may occur by increasing motion through the subtalar axis that result in increased dorsiflexion, in addition to valgus of the hind foot and abduction of the forefoot. This compensation leads to over protonation of the foot which tends to increase stress on the plantar fascia and other musculotendinous structures supporting the arch leading to the development of plantar fasciopathy and flatfoot [30].

In the current study, the improvement in foot function established in patients of both groups may also be linked to the effect of therapeutic ultrasound in addition to the effect of moist heat application. Therapeutic ultrasound was reported to stimulate the healing process [11], while moist heat was proved to improve the local circulation and decrease plantar fascia pain significantly [31]. Sullivan et al. (2015) [32]. stated that weakness in both the intrinsic and extrinsic foot muscles may result in recurrence of symptoms in patients with PF due to improper functioning of muscles and joint positioning during walking. Strengthening the intrinsic foot muscles is, therefore an important factor to counterbalance the overdue stresses affecting the plantar fascia [24], Wei et al. (2022) [33] reported that intrinsic foot muscle training can exert positive biomechanical effects on the medial longitudinal arch and improve dynamic postural balance. Strengthening of the intrinsic foot muscles introduced for all participants in the current study may have been another reason for the improvement in heel pain reported by participants.

The significant decrease in the OSI and FFI post-treatment compared to that pre-treatment in the flossing exercise group may be attributed to improved flexibility of the hamstring muscle because of the application of the flossing band. Behm et al. (2019) [34] reported that using flossing band generates compressive stress on the target muscle, skin and fascia, affecting fluid viscosity and leading to less resistance to movement. In the same context, Kaneda et al. (2020) [15] demonstrated that flossing band produces restriction of the blood flow and localized vascular occlusion, affects how the fascia interacts with the neuromuscular system, thereby, allowing the fascia to stretch and move freely. Kaneda et al. (2020) [15] also reported that flossing band applied to the hamstring muscles is more beneficial than dynamic stretching in terms of increasing hamstring muscle flexibility in healthy young men.

Between subject effect

Of the findings of the current study was the insignificant statistical difference in the OSI and FFI between the control and experimental groups. This may be because the conventional treatment program introduced to patients in the current study was a complementary program that included stretching of the gastrocnemius muscle. Gastrocnemius muscle stretching may have led to indirect increase in hamstring muscles flexibility [35], which was the main aim of using the hamstring flossing.

Myers, (2009) [36] described the superficial fascia of the back as a myofascial chain which is considered as a superficial back line that connects the hamstring muscle proximally with the gastrocnemius muscle and the plantar fascia distally. Accordingly, it was concluded that hamstring flexibility enhances the effect of stretching tight calf muscles, improves foot pain and function. In the same context, Fauris et al. (2021) [37] stated that performing flexibility training on any segment of the superficial back line results in a significant increase in flexibility of the hamstring and calf muscles and a subsequent increase in the range of ankle dorsiflexion. Although adding hamstring flexibility to the traditional physical therapy program for treatment of plantar fasciopathy may be of a great value, yet the specific distal targeting program to the plantar fascia still have a great effect [38]. This may be a reason why there was no statistically significant difference detected between the effects of the two interventions carried out in the current study.

When the gastrocnemius muscle is shortened, pain is felt in the calf muscles before the hamstring muscles. This Calf muscles shortening makes it challenging to continue with the hamstring flexibility test, and leads to extreme soreness in the gastrocnemius, preventing the person from completely extending the hamstring [39]. Following this speculation, Russell et al. (2010) [35] conducted a study to examine the effectiveness of stretching hamstrings-only, gastrocnemius-only, and combined hamstrings-gastrocnemius on knee extensibility measured by active knee extension test. Their findings revealed that the influence of the gastrocnemius stretching was of particular interest, which come in agreement with the results of the current study. Russell et al. (2010) [35] also stated that as the gastrocnemius is a two-joint muscle, spanning the knee and ankle joints, its posterior position is most likely the cause of greater knee extensibility during gastrocnemius stretching.

Contrasting Opinions

Opposing to the findings of the current study were the findings of the study carried out by Radford et al. (2007) [40] who investigated the short term (two weeks) effect of calf muscle stretching on foot function in 92 participants suffering from plantar fasciitis. They concluded that short-term calf muscle stretching had no significant effect on the improvement of first-step pain, foot pain, foot function or even general foot health as compared to non-stretching. This controversy may be linked to the difference in the treatment protocols used in the current study and that of Radford et al. (2007) [40]. Stretching of the Achilles tendon in the study by Radford et al. (2007) [40] was done on a wedge. Participants noticed that the use of the wooden wedge placed increased pressure under the heel as the position of the foot on the wedge during the stretching procedure redistributed force away from the forefoot to the plantar heel region. This could be the cause that led to inability of the patients to feel better concerning pain level. While in the current study the stretching protocol was in the form of lunge Achilles tendon stretch which is a type of dynamic stretching [40]. Lee, J., & Kim, J. (2022) [41] showed that lunge exercise improves muscle strength. The increased muscle strength of the extrinsic foot muscles may partly due to the increased flexibility of muscle and plantar fascia obtained from the stretching exercise. Muscle weakness in patients PF impairs the dynamic arch's ability to stabilize the foot's longitudinal arch and reduce ground reaction forces [42]. Then, this is compensated by the increase of additional stress on plantar fascia which is the passive support structure of the foot [42].

The findings of the current study come in agreement with the findings obtained by increased muscle strength of the extrinsic foot muscles may partly due to the increased flexibility of muscle and plantar fascia obtained from the stretching exercise Wu et al. (22) [43] who investigated the effects of hamstring flossing as compared to elastic bandage control band on knee ROM and static balance in healthy women. They concluded that the application of flossing band to the knee improves hamstring flexibility without impeding static balance.

Study limitations

- There was not a non-intervention group in this study; hence, it cannot quantify the spontaneous progression of the symptoms

- The amount of pressure produced by the flossing band varied according to discomfort and knowledge to use flossing.
- Inability to generalize the results beyond the targeted age group and gender.

- This study lacked performing balance training and its effect of function in patients with plantar fasciopathy.

- Short intervention duration

Future study to compare with placebo or sham treatment is necessary to find out the effect of isolated hamstring flossing in case of plantar fasciitis. Also, future study included non-intervention group so, it can measure spontaneous progression of symptoms. Adding neuromuscular training of the ankle and foot muscles, and studying its long term effect may be useful for patients with PF. Finally, it is recommended to examin the effect of balace training on patients with plantar fasciopathy

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'Conflict of interest: none'.

Conclusion

Adding hamstring flossing to the conventional physical therapy treatment program for PF does not significantly improve neither the patient's foot function nor balance as compared to the conventional physical therapy treatment alone.

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Authors' contributions

Conceptualization and supervision : Amal Abdelrahman Elborady; Yassmin Essam Mohamed
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Data analysis: Eman Ahmed Ahmed
Investigation and writing: Eman Ahmed Ahmed; Amal Abdelrahman Elborady; Yassmin Essam Mohamed

Conflict of interest

The authors declared no conflict of interest.

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