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Effects of Tibialis Posterior Strengthening Combined with Plantar Fascia-Specific Stretching on Muscle Strength and Foot Function in Individuals with Plantar Fasciitis

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Abstract **Background:** Plantar fasciitis is a common musculoskeletal condition associated with plantar heel pain and limitations in weight-bearing activities. The tibialis posterior dynamically supports the medial longitudinal arch, however, clinical evidence on targeted strengthening programmes for individuals with plantar fasciitis remains limited. **Objective:** To compare changes in tibialis posterior muscle strength and foot function following a six-week programme combining tibialis posterior strengthening with plantar fascia-specific stretching versus conventional exercises and conservative advice in individuals with plantar fasciitis. **Methods:** This randomised comparative intervention study included 42 adults aged 25–50 years with plantar fasciitis, allocated to two groups of 21 participants each. Group A received tibialis posterior-focused strengthening combined with plantar fascia-specific stretching, whereas Group B received gastrocnemius and soleus stretching, footwear advice, activity modification, and symptom-relief measures. Both programmes were administered three times weekly for six weeks. Tibialis posterior muscle strength was assessed using a modified sphygmomanometer, and foot-related symptoms and disability were evaluated using the Foot Function Index (FFI). Assessments were conducted at baseline, week 3, and week 6. **Results:** Descriptive findings indicated improvements in both groups. Mean tibialis posterior strength increased from 43.00 to 58.50 mmHg in Group A and from 42.25 to 50.25 mmHg in Group B. Mean FFI scores decreased from 54.50 to 26.00 in Group A and from 56.25 to 40.75 in Group B. The unadjusted between-group differences in mean change were 7.50 mmHg for muscle strength and 13.00 FFI points, favouring Group A. However, inconsistencies between the reported sample size and inferential-test degrees of freedom prevent confirmation of statistical significance from the available data. **Conclusion:** Both intervention programmes demonstrated favourable descriptive changes in muscle strength and foot function over six weeks, with larger mean changes observed in the combined tibialis posterior strengthening and plantar fascia-specific stretching group. These findings should be interpreted cautiously because statistical superiority and clinical importance remain unconfirmed pending participant-level reanalysis.

Key Words: Plantar Fasciitis, Tibialis Posterior, Strengthening Exercises, Foot Function Index, Physiotherapy

INTRODUCTION

Plantar fasciitis, also termed plantar fasciopathy, is a common musculoskeletal cause of plantar heel pain. Typical symptoms include pain near the medial calcaneal region, particularly during the first steps after waking or following prolonged rest. Pain may also increase with prolonged standing, walking, and other weight-bearing activities. Contemporary literature describes plantar fasciitis as a multifactorial condition involving repetitive mechanical loading and changes in the plantar fascia rather than a purely inflammatory disorder [1–3].

The plantar fascia provides passive support for the medial longitudinal arch and helps distribute mechanical loads during weight-bearing. Foot structure, gait mechanics, loading exposure, and the function of surrounding musculature may influence the mechanical environment of the plantar fascia [3–6]. Nevertheless, the mechanisms associated with plantar heel pain vary between individuals, and no single biomechanical factor explains every presentation.

The tibialis posterior is an important muscle involved in foot inversion and dynamic support of the medial longitudinal arch. Experimental biomechanical research has demonstrated its contribution to arch behaviour under axial loading [4,7]. Consequently, exercises aimed at improving tibialis posterior strength and control may help address foot function. However, biomechanical evidence does not establish that tibialis posterior weakness is the primary cause of plantar fasciitis or that strengthening this muscle alone reduces plantar fascia symptoms.

Conservative management generally incorporates patient education, activity modification, stretching, appropriate footwear, and exercise-based rehabilitation. Clinical guidance recommends plantar fascia-specific stretching and gastrocnemius–soleus stretching and supports therapeutic exercise that includes resistance training for foot and ankle musculature [8-9]. Plantar fascia-specific stretching has demonstrated benefits in clinical studies of chronic plantar fasciitis, while calf stretching has also been investigated as a conservative intervention [10-11]. Systematic reviews indicate that therapeutic exercise is commonly incorporated into plantar fasciitis management, although the evidence for individual strengthening approaches remains less developed than the evidence for stretching-based interventions [12-14].

Randomised research has examined combinations of stretching and strengthening for plantar fasciitis, while other studies have investigated insoles, footwear, and related conservative approaches [15-16]. These studies provide context for multimodal rehabilitation but do not establish the isolated contribution of tibialis posterior strengthening. A targeted programme may be biologically plausible, but its effect should be evaluated through appropriate clinical outcomes and a clearly defined comparison.

Evidence concerning intrinsic foot muscle exercise provides additional, indirect support for investigating exercise-based approaches to foot function. Reviews have evaluated foot muscle training and its effects on muscle size, strength, balance, and biomechanical outcomes [17-20]. However, intrinsic foot muscles and the tibialis posterior are anatomically and functionally distinct. Findings from intrinsic muscle interventions should therefore not be interpreted as direct evidence of tibialis posterior strengthening efficacy.

Studies of foot muscle strength measurement also highlight the importance of reliable testing procedures. Researchers have investigated the modified sphygmomanometer test as a practical method for assessing muscle strength in clinical populations [21,22] Its use requires standardisation of positioning, stabilisation, cuff placement, and testing procedures. The Foot Function Index is a patient-reported measure of foot-related pain and disability, and researchers have systematically reviewed its measurement properties [23].

Recent studies and evidence syntheses continue to examine exercise-based and multimodal approaches to plantar fasciopathy, including therapeutic exercise, home programmes, and patient advice [24-26].

Although the tibialis posterior contributes to dynamic stabilisation of the medial longitudinal arch, the clinical effectiveness of targeted tibialis posterior strengthening in individuals with plantar fasciitis remains insufficiently established. Previous investigations have examined plantar fascia-specific stretching, calf stretching, intrinsic foot muscle strengthening, and multimodal exercise programmes. However, findings from intrinsic foot muscle training cannot be directly extrapolated to the tibialis posterior because these muscles differ anatomically and functionally. Furthermore, the biomechanical contribution of the tibialis posterior to arch stability alone does not show that strengthening this muscle reduces plantar heel pain or improves foot-related function.

This study addresses this gap by comparing a structured programme combining tibialis posterior strengthening and plantar fascia-specific stretching with conventional exercises and conservative advice. Because the interventions differ in multiple treatment components, the study evaluates the comparative outcomes of two rehabilitation packages rather than the independent therapeutic contribution of tibialis posterior strengthening.

Accordingly, this study aimed to compare changes in tibialis posterior muscle strength and Foot Function Index scores over a six-week intervention period, with assessments conducted at baseline, week 3, and week 6. The comparison was intended to determine whether the combined targeted programme demonstrated more favourable descriptive changes than the conventional programme, while recognising that confirmation of between-group statistical differences requires appropriate repeated-measures analysis.

Aim and Objectives

Aim: To compare the effects of tibialis posterior strengthening combined with plantar fascia-specific stretching versus conventional exercises on tibialis posterior muscle strength and foot function in individuals with plantar fasciitis.

Objectives

- To assess tibialis posterior muscle strength using a modified sphygmomanometer at baseline, week 3, and week 6 in both intervention groups
- To evaluate foot-related symptoms and disability using the Foot Function Index at baseline, week 3, and week 6
- To determine the baseline-to-week-6 changes in tibialis posterior muscle strength and Foot Function Index scores within each intervention group
- To compare the descriptive patterns of change in muscle strength and foot function between the combined targeted programme and conventional exercise programme

Materials and Methods

Study Design

This study employed a randomised, two-group, parallel comparative intervention design to evaluate changes in tibialis posterior muscle strength and foot function among individuals with plantar fasciitis. The intervention lasted six weeks, with outcome assessments at baseline, week 3, and week 6.

Participants were allocated to either Group A, which received tibialis posterior strengthening combined with plantar fascia-specific stretching, or Group B, which received conventional exercises and conservative advice. Both programmes were scheduled three times weekly throughout the intervention period.

The study was designed to compare the outcomes of the two rehabilitation programmes. As the interventions differed in several components, the study was not designed to isolate the independent effect of tibialis posterior strengthening.

Participants and Sampling

A total of 42 adults aged between 25 and 50 years with a clinical diagnosis of plantar fasciitis were included in the study. Participants were recruited using convenience sampling and allocated to two intervention groups (21 participants per group).

Inclusion Criteria

Participants were eligible if they fulfilled the following criteria:

- Adults aged 25–50 years with a clinical diagnosis of plantar fasciitis
- Plantar heel pain persisting for at least three months
- Characteristic pain during the first steps after waking or following a period of rest
- Ability to walk independently
- Willingness to participate in the six-week intervention programme

Exclusion Criteria

Participants were excluded if they had:

- A history of foot or ankle surgery
- Recent lower-limb fracture or significant trauma
- Neurological disorders affecting the lower limbs
- Tibialis posterior tendon dysfunction or significant tendinopathy
- Inflammatory joint disease
- Inability or unwillingness to follow the prescribed intervention programme

Participants underwent outcome assessments before the intervention, at week 3, and at the completion of week 6. Tibialis posterior muscle strength and foot-related symptoms and disability were evaluated using the modified sphygmomanometer procedure and Foot Function Index, respectively.

Sample-Size Calculation

Sample size was estimated using G*Power software for a repeated-measures design involving two groups and three assessment points, assuming an effect size of 0.50, $\alpha = 0.05$, 80% power, and a correlation of 0.50 between repeated measurements. The reported minimum sample size was 24 participants, however, 42 participants (21 per group) were recruited for the study.

Intervention Procedures

Participants received their allocated intervention three times per week for six consecutive weeks. The intervention programmes were designed to address muscle performance, flexibility, and foot-related functional limitations.

Group A: Tibialis Posterior Strengthening Combined with Plantar Fascia-Specific Stretching

Group A participants received a targeted exercise programme that included three strengthening exercises and plantar fascia-specific stretching.

Exercise 1: Resisted Foot Inversion with Slight Plantar Flexion

Participants were seated with a resistance band anchored laterally. They performed ankle inversion with slight plantar flexion against resistance, then returned to the starting position under control.

- **Sets:** 2
- **Repetitions:** 10–15 per set
- **Hold Duration:** 10 seconds
- **Rest Between Repetitions:** 15 seconds
- **Rest Between Sets:** 60 seconds

Exercise 2: Seated Resisted Heel Raises

Participants performed heel raises in a seated position with resistance applied around the forefoot. Emphasis

was placed on maintaining appropriate foot alignment and controlled movement during the raising and lowering phases.

- **Sets:** 2
- **Repetitions:** 10–15 per set
- **Hold Duration:** 10 seconds
- **Rest Between Repetitions:** 15 seconds
- **Rest Between Sets:** 60 seconds

Exercise 3: Side-Lying Resisted Ankle Inversion
Participants were positioned in side-lying with the affected lower limb uppermost. A resistance band was placed around the forefoot, and controlled ankle inversion was performed against resistance.

- **Sets:** 2
- **Repetitions:** 10–15 per set
- **Hold Duration:** 10 seconds
- **Rest Between Repetitions:** 15 seconds
- **Rest Between Sets:** 60 seconds

Exercise 4: Plantar Fascia-Specific Stretching
Participants were seated with the affected lower limb crossed over the opposite leg. The toes were gently extended, and the ankle was dorsiflexed until a tolerable stretch was perceived along the plantar aspect of the foot.

- **Sets:** 2–3
- **Hold Duration:** 30–45 seconds
- **Rest Between Sets:** 15–30 seconds

Resistance was intended to progress according to exercise tolerance and performance. The exact progression criteria and resistance-band specifications require confirmation from the original intervention documentation.

Group B: Conventional Exercises and Conservative Advice
Group B participants received conventional stretching exercises and conservative management advice.

Exercise 1: Gastrocnemius Stretching
Participants stood with the affected lower limb positioned behind the opposite leg. The rear knee was maintained in extension, and the heel remained in contact with the floor while the calf was stretched.

Exercise 2: Soleus Stretching
Participants adopted a similar standing position, with the rear knee slightly flexed to emphasise soleus stretching.
For both stretching exercises:

- **Sets:** 2–3
- **Hold Duration:** 30–45 seconds
- **Rest Between Sets:** Approximately 15 seconds

Participants were also advised to wear comfortable, supportive footwear, modify activities that aggravated symptoms, and use ice application or gentle massage as tolerated.

Intervention Comparison
The two programmes differed in their exercise components and conservative-care measures. Group A received targeted tibialis posterior strengthening and plantar fascia-specific stretching, whereas Group B received calf stretching and conservative advice. Consequently, the intervention comparison represents the combined effects of the respective rehabilitation packages rather than the isolated effect of tibialis posterior strengthening.

Outcome Measures
Tibialis Posterior Muscle Strength: We assessed muscle strength using a modified sphygmomanometer procedure and expressed it in mmHg. The method was selected as a practical clinical measurement approach. Published work has evaluated modified sphygmomanometer testing for muscle strength assessment, including reliability and validity in clinical populations [21-22].

The final study report must specify the exact testing position, stabilisation method, cuff preparation and placement, familiarisation procedure, number of trials, rest intervals, and value used for analysis. The reliability of the specific tibialis posterior testing protocol should not be assumed solely from studies of other muscle groups.

Foot Function Index
Foot-related symptoms and disability were assessed using the Foot Function Index. The FFI is a patient-reported outcome measure intended to quantify foot-related pain and functional limitation. Its measurement properties have been systematically reviewed [23]. The exact version, language, scoring procedure, transformation to a 0–100 scale, and handling of missing responses must be reported. Under the same scoring convention, lower scores indicate fewer foot-related problems.

Assessment Schedule
Both outcomes were recorded at:

- Baseline, before the intervention
- Week 3, during the intervention period
- Week 6, at the end of the intervention

Statistical Analysis
Descriptive statistics were used to summarise the available participant characteristics and outcome measurements. We presented continuous variables as means and standard deviations, while categorical demographic variables were presented as frequencies and percentages.

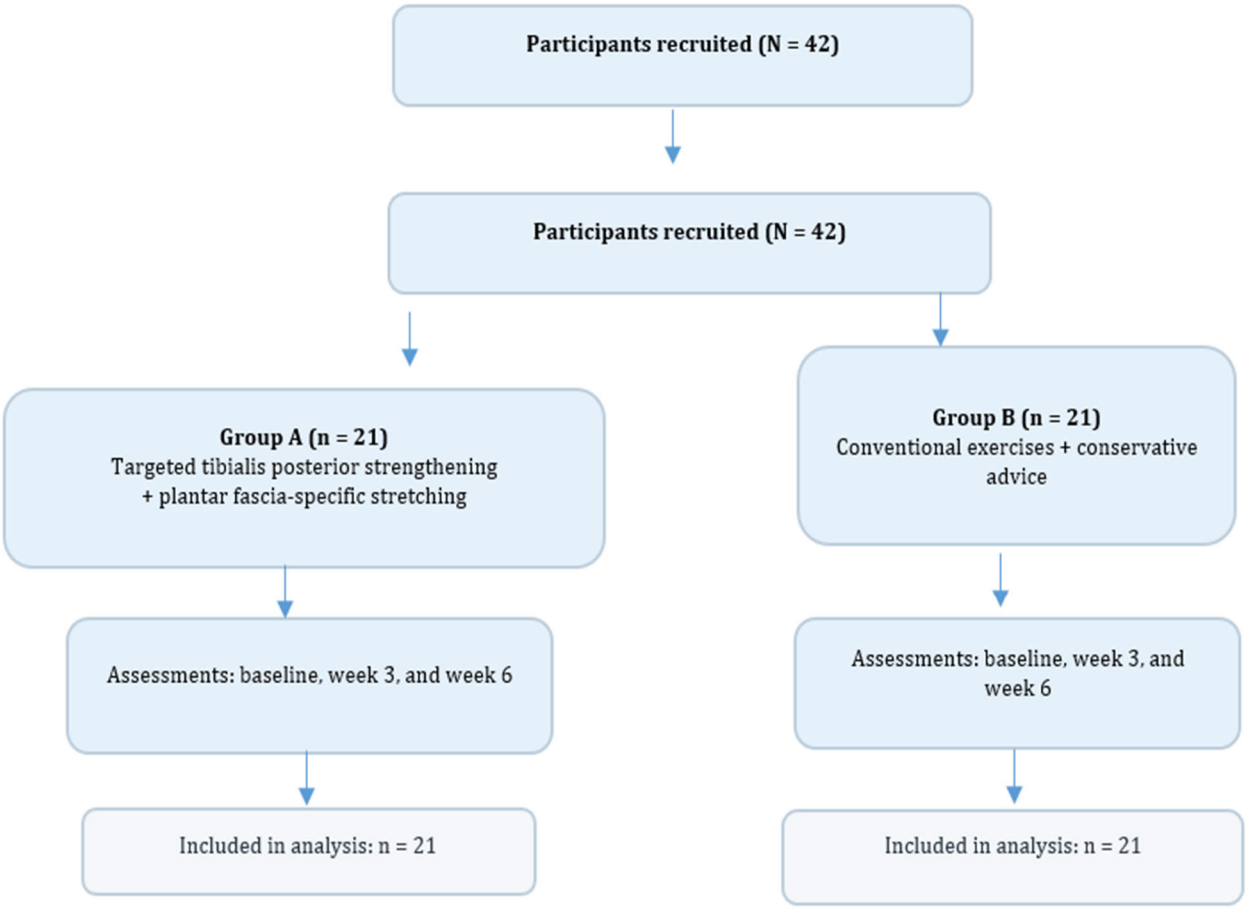


Figure 1: Flow Chart

We summarised tibialis posterior muscle strength and Foot Function Index scores separately for each intervention group at baseline, week 3, and week 6. We calculated baseline-to-week-6 mean changes by subtracting baseline group means from the corresponding week-6 group means. Between-group differences in descriptive change were calculated by comparing these changes between Group A and Group B Figure 1.

RESULTS

Participant Characteristics

The supplied demographic summary included 42 participants (21 per group).

A total of 42 participants with plantar fasciitis were included in the study, with 21 participants allocated to Group A and 21 to Group B. The mean age was 35.24±6.82 years in Group A and 36.10±7.15 years in Group B. The overall mean age was 35.67±6.95 years.

Group A comprised 9 men (42.9%) and 12 women (57.1%), whereas Group B comprised 10 men (47.6%) and 11 women (52.4%). Overall, the study included 19 men (45.2%) and 23 women (54.8%).

The reported baseline demographic characteristics are presented in Table 1. No inferential comparison of baseline demographic characteristics is presented.

Tibialis Posterior Strength and Foot Function

The summary values showed increased tibialis posterior strength and reduced FFI scores in both groups during the six-week intervention.

The reported descriptive data demonstrated increases in tibialis posterior muscle strength in both intervention groups over the six-week intervention period.

In Group A, mean muscle strength increased from 43.00±2.58 mmHg at baseline to 50.00±2.58 mmHg at week 3 and 58.50±3.11 mmHg at week 6. The baseline-to-week-6 increase in mean strength was 15.50 mmHg.

In Group B, mean muscle strength increased from 42.25±2.22 mmHg at baseline to 46.25±2.22 mmHg at week 3 and 50.25±2.22 mmHg at week 6. The baseline-to-week-6 increase in mean strength was 8.00 mmHg.

The unadjusted between-group difference in mean strength change was 7.50 mmHg, favouring Group A. These results indicate a larger descriptive increase in muscle strength following the combined targeted programme (Table 2).

Table 1: Demographic Characteristics of the Participants

Characteristic	Group A (n = 21)	Group B (n = 21)	Total (N = 42)
Age, years, Mean±SD	35.24±6.82	36.10±7.15	35.67±6.95
Men, n (%)	9 (42.9%)	10 (47.6%)	19 (45.2%)
Women, n (%)	12 (57.1%)	11 (52.4%)	23 (54.8%)

Table 2: Descriptive Outcomes at Baseline, Week 3, and Week 6

Outcome	Group	Baseline, Mean±SD	Week 3, Mean±SD	Week 6, Mean±SD	Baseline-to-week-6 change
Tibialis posterior strength (mmHg)	A: Targeted programme	43.00±2.58	50.00±2.58	58.50±3.11	+15.50
Tibialis posterior strength (mmHg)	B: Conventional programme	42.25±2.22	46.25±2.22	50.25±2.22	+8.00
FFI score	A: Targeted programme	54.50±5.20	40.50±3.87	26.00±2.58	−28.50
FFI score	B: Conventional programme	56.25±4.79	48.75±4.27	40.75±3.50	−15.50

Inferential Analysis

The original draft reported statistically significant time effects and group-by-time interactions. However, the stated participant numbers conflict with the table footnote and the reported degrees of freedom. These statistics have not been reproduced as verified findings. The final Results section should be updated after the original dataset is reanalysed. Corrected model estimates, degrees of freedom, p-values, effect sizes, 95% confidence intervals, and adjusted comparisons should be reported as appropriate.

DISCUSSION

Principal Findings

This study compared a six-week tibialis posterior strengthening programme combined with plantar fascia-specific stretching against conventional exercises and conservative advice in individuals with plantar fasciitis. The descriptive findings demonstrated improvements in tibialis posterior muscle strength and Foot Function Index scores in both intervention groups. However, the combined targeted programme demonstrated larger mean changes in both outcomes.

Group A showed a mean increase of 15.50 mmHg in tibialis posterior muscle strength, compared with 8.00 mmHg in Group B. Similarly, the mean reduction in FFI score was 28.50 points in Group A and 15.50 points in Group B. The unadjusted between-group differences in mean change were 7.50 mmHg for muscle strength and 13.00 FFI points, favouring Group A.

Role of Tibialis Posterior Strengthening in Foot Mechanics

The tibialis posterior dynamically stabilises the medial longitudinal arch and helps control foot movement during weight-bearing activities. Biomechanical investigations have demonstrated the contribution of the tibialis posterior and plantar soft tissues to longitudinal arch stability [4-5,7].

The larger increase in measured tibialis posterior strength in Group A supports incorporating targeted resistance exercises into foot and ankle rehabilitation. However, improved muscle strength does not necessarily demonstrate corresponding changes in arch mechanics, plantar pressure distribution, or plantar fascia loading.

Previous research investigating intrinsic foot muscle strengthening has reported outcomes related to foot strength, posture, balance, and function [17-20]. Nevertheless, intrinsic foot muscles and the tibialis posterior differ anatomically and functionally. Therefore, findings from intrinsic foot muscle training should be considered indirect evidence rather than confirmation of the efficacy of tibialis posterior strengthening.

Alam *et al.* [27] investigated selective tibialis posterior strengthening in individuals with pronated feet. Although this study provides a relevant biomechanical context, findings from individuals with pronated feet cannot be directly generalised to individuals with clinically diagnosed plantar fasciitis.

Changes in Foot Function

Both intervention groups showed reductions in FFI scores, with a larger reduction in Group A. The FFI is a patient-reported outcome measure that assesses foot-related pain and disability, and previous research has examined its measurement properties [23].

The observed reductions in FFI scores may reflect improvements in reported foot-related symptoms and functional limitations during the intervention period. However, these changes may be influenced by several factors, including stretching, strengthening, footwear modification, activity modification, exercise exposure, participant expectations, and natural variations in symptoms.

The study did not measure pain intensity, gait parameters, plantar pressure distribution, or foot posture separately. Therefore, the specific mechanisms responsible for the observed changes in FFI scores cannot be determined.

Furthermore, without an appropriate prespecified clinically important difference or responder threshold, the clinical importance of the observed FFI changes cannot be established.

Comparison with Previous Literature

The descriptive findings are compatible with existing evidence supporting exercise-based and multimodal rehabilitation for plantar fasciitis. Contemporary clinical practice guidance recommends plantar fascia-specific stretching, gastrocnemius–soleus stretching, and resistance training involving foot and ankle musculature [9].

DiGiovanni *et al.* [10] investigated plantar fascia-specific stretching in individuals with chronic plantar fasciitis, while Radford *et al.* [11] examined calf stretching for plantar heel pain. These investigations provide clinical context for the stretching components included in the present intervention programmes.

Kamonseki *et al.* [15] investigated stretching with and without additional strengthening exercises in patients with plantar fasciitis. Systematic reviews and meta-analyses have also evaluated therapeutic exercise and other physiotherapeutic interventions for plantar fasciitis [12-14,24].

Collectively, the existing literature supports the continued investigation of structured exercise programmes for plantar fasciitis. However, differences in exercise selection, dosage, comparator interventions, outcome measures, and study populations limit direct comparisons between individual treatment protocols.

The present study contributes a descriptive comparison of a combined tibialis posterior strengthening and plantar fascia-specific stretching programme against conventional exercises and conservative advice. Nevertheless, the independent contribution of tibialis posterior strengthening remains uncertain.

Interpretation of the Intervention Comparison

An important consideration in interpreting the findings is that the two intervention groups received different treatment packages.

Group A received targeted tibialis posterior strengthening combined with plantar fascia-specific stretching, whereas Group B received gastrocnemius and soleus stretching, footwear advice, activity modification, and symptom-relief measures.

Consequently, the observed differences between groups cannot be attributed exclusively to tibialis posterior strengthening. Plantar fascia-specific stretching, differences in exercise exposure, conservative advice, and other intervention-related factors may have contributed to the observed outcomes.

A future study in which both groups receive identical background care, with tibialis posterior strengthening added only to the experimental group, would provide a more direct evaluation of the independent contribution of targeted strengthening.

Clinical Implications

The descriptive findings suggest that a combined programme incorporating tibialis posterior strengthening and plantar fascia-specific stretching may warrant further investigation as part of conservative rehabilitation for individuals with plantar fasciitis.

However, these results do not establish statistical superiority, clinical importance, or universal effectiveness. Physiotherapists should continue to individualise exercise prescription according to symptoms, functional limitations, exercise tolerance, and patient response.

The findings should not be interpreted as evidence that the intervention corrects excessive pronation, reduces plantar fascia loading, improves gait biomechanics, or prevents recurrence, because these outcomes were not directly evaluated.

Strengths and Limitations

The study included two intervention groups and repeated assessments at baseline, week 3, and week 6, allowing descriptive changes in muscle strength and foot-related function to be examined over time. Including both a physical impairment measure and a patient-reported functional outcome is a methodological strength.

However, several limitations should be acknowledged. First, convenience sampling may restrict the generalisability of the findings. Second, the relatively small sample size and the need to verify the original sample-size calculation may reduce confidence in the study's statistical adequacy.

Third, the intervention packages differed in multiple components, preventing isolation of the independent effects of tibialis posterior strengthening. Fourth, the six-week intervention period and absence of reported long-term follow-up limit conclusions regarding sustained benefits and recurrence prevention.

Fifth, the available study documentation provides insufficient information on allocation concealment, assessor blinding, intervention adherence, protocol deviations, adverse events, or participant attrition.

Sixth, the modified sphygmomanometer procedure requires further documentation regarding testing standardisation and the reliability of the specific tibialis posterior measurement protocol. In addition, the study did not provide separate measurements of pain intensity, gait parameters, plantar pressure distribution, or foot posture.

Recommendations for Future Research

Future studies should use adequately powered randomised controlled designs with clearly documented sequence generation, allocation concealment, and, where feasible, blinded outcome assessment.

To determine the independent contribution of tibialis posterior strengthening, future trials should provide equivalent background care to both groups and vary only the targeted strengthening component.

Further research should also include standardised exercise progression, adherence monitoring, documentation of co-interventions and adverse events, and longer-term follow-up.

Additional outcomes such as pain intensity, foot posture, plantar pressure distribution, gait parameters, and patient-rated global improvement may provide a more comprehensive understanding of the effects of targeted foot and ankle rehabilitation.

Future analyses should report verified between-group estimates, confidence intervals, effect sizes, and appropriate adjustments for repeated measurements and multiple comparisons.

CONCLUSIONS

The present study compared a six-week tibialis posterior strengthening programme combined with plantar fascia-specific stretching against conventional exercises and conservative advice in individuals with plantar fasciitis.

The reported descriptive findings demonstrated increases in tibialis posterior muscle strength and reductions in Foot Function Index scores in both intervention groups. The combined targeted programme showed larger mean changes in both outcomes than the conventional programme.

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Author Contributions

Syed Ali Shifa A**:** Conceptualization, methodology, literature search, study selection, data extraction, data curation, and manuscript drafting, Shenbaga Sundaram Subramanian: Conceptualization, methodology, supervision, critical revision of the manuscript, and overall oversight of the review, Kavitha Ramanathan, Vasanthakumari Sundararajan, and Porkodi Arjunan**:** Data analysis, interpretation of findings, manuscript review, and critical revision, Ammar E. Hafiz**:** Literature search, study screening, data extraction, data synthesis, and manuscript review, Riziq Allah Mustafa Gaowgzeh**:** Literature search, study screening, data extraction, data curation, and manuscript preparation, Baraa Alsulaimani**:** Methodology, data synthesis, interpretation of findings, and critical revision of the manuscript, Bawazir Raad and Khalid A Alsayed**:** Data synthesis, interpretation of findings, manuscript review, and editing. All authors contributed to the development and/or revision of the manuscript, approved the final version, and agreed to be accountable for all aspects of the work.

Disclosure of Conflicts of Interest

The authors report no conflicts of interest.

Data Availability Statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki. It was approved by the Institutional Scientific Review Board of Saveetha College of Physiotherapy (Approval No: 004/05/2025/ISRB/UGSR/SCPT).

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Declaration of Generative AI in Scientific Writing

No generative artificial intelligence or AI-assisted technologies were used in the preparation, writing, analysis or editing of this manuscript.

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