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Effect of Short Foot Exercises on Pain and Foot Posture in Patients with Acquired Pes Planus

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ABSTRACT
Background: Pes planus, or flatfoot, is a prevalent musculoskeletal condition characterized by collapse of the medial longitudinal arch and excessive pronation, often leading to foot pain and postural imbalance during weight-bearing activities. Conventional management focuses on footwear modification and orthoses; however, intrinsic muscle training has recently gained attention for restoring dynamic arch stability through neuromuscular re-education (1–3). Objective: To evaluate the effect of a six-week short-foot exercise (SFE) program on pain and foot posture in adults with acquired flexible pes planus. Methods: A quasi-experimental study was conducted among 41 participants aged 18–35 years with bilateral flexible pes planus (FPI 6–12, navicular drop >10 mm). Participants were divided into treatment (n = 21) and control (n = 20) groups. The treatment group performed progressive short-foot exercises (seated → double-leg → single-leg stance) daily for six weeks, while controls received only education and footwear advice. Pain intensity was assessed using the Visual Analogue Scale (VAS), and foot posture was evaluated using the Foot Posture Index (FPI) and Navicular Drop Test (NDT). Nonparametric tests (Mann–Whitney U, Wilcoxon signed-rank) and Cohen's d effect sizes were computed with significance set at $p < 0.05$. Results: Post-intervention, the treatment group demonstrated significant reductions in pain (VAS: 7.10 ± 1.09 to 4.14 ± 1.11, $p < 0.001$, $d = 1.30$) and improved right-foot posture (FPI: 7.05 ± 0.91 to 6.19 ± 0.40, $p < 0.001$; NDT: 11.8 ± 1.4 mm to 10.6 ± 1.1 mm, $p = 0.006$). No significant changes were observed in the left foot ($p > 0.17$). Ninety-five percent of treated participants achieved ≥30% pain reduction versus 35% in controls ($\chi^2 = 15.7$, $p < 0.001$). Conclusion: Short-foot exercises significantly reduce pain and enhance right-foot posture in flexible pes planus, offering an effective, low-cost, and noninvasive rehabilitation strategy for improving intrinsic muscle control and medial arch function.

Keywords
Pes planus; Flatfoot; Short-foot exercises; Foot posture index; Navicular drop; Intrinsic foot muscles.

INTRODUCTION
Pes planus is characterized by a flattening of the medial longitudinal arch that alters load distribution across the foot–ankle complex, amplifies pronation moments, and is frequently associated with pain and functional limitation in weight-bearing tasks (1). Although rigid and flexible phenotypes are recognized, flexible flatfoot in young adults is clinically important because symptoms often emerge with prolonged standing, walking, or sport and may propagate proximal kinetic-chain consequences if left unaddressed (2). Epidemiological reports indicate substantial population burden and co-occurrence with modifiable risk factors such as elevated body mass index, ligamentous laxity, and posterior tibial tendon dysfunction, supporting the need for conservative, scalable interventions that address both symptoms and foot posture (3,4).
Short-foot exercises (SFE) target intrinsic foot muscles to actively elevate and stiffen the medial arch by drawing the first metatarsal head toward the calcaneus without toe flexion, thereby improving sensorimotor control, arch height, and mediolateral stability during stance (5). Mechanistic and experimental work shows SFE can increase abductor hallucis cross-sectional area and activation, reduce navicular drop, and favorably modify medial longitudinal arch angle compared with resting or non-specific foot movements (6,7). A recent meta-analysis in flatfoot individuals reported improvements in alignment indices and surrogate markers of intrinsic muscle hypertrophy after SFE protocols, though heterogeneity in dosing, supervision, and outcome definitions limited certainty and generalizability to symptomatic adults (8). Comparative trials suggest SFE may yield benefits similar to or complementary with orthoses and may provide additive effects when combined with hip–knee strategies that modulate distal alignment via proximal control, yet pain outcomes and validated posture composites such as the Foot Posture Index (FPI) are inconsistently reported, and side-specific responses are rarely analyzed (6,9,10).
From a clinical perspective, an intervention that is low cost, equipment-free, and feasible to implement in outpatient practice could fill a pragmatic gap between education/footwear advice and device-based approaches, particularly for young adults with flexible pes planus who present with pain but may not meet thresholds for bracing or surgery (3,11). However, the literature remains limited by small samples, variable adherence monitoring, and insufficient reporting of effect sizes alongside distribution-based and clinically anchored metrics such as changes in pain on a visual analogue scale (VAS) and FPI category shifts (8–10). Additionally, navicular drop—a commonly used proxy for dynamic arch collapse—requires

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clarification of measurement reliability and its relationship to patient-reported pain in this population, as prior studies have emphasized surrogate biomechanics over symptomatic endpoints (5,7,8).

Accordingly, this study evaluates whether a six-week, progressively loaded SFE program, delivered alongside usual education and footwear advice, reduces pain and improves foot posture relative to usual care alone in adults with flexible pes planus, using VAS for pain, FPI for global posture, and navicular drop as an index of arch mechanics (1,5,8). The research problem is the persistent gap in high-quality, clinically interpretable evidence quantifying SFE effects on both symptoms and validated posture outcomes in symptomatic flexible flatfoot. The knowledge gap centers on inconsistent pain reporting, limited side-specific analysis, and inadequate effect-size presentation in prior work. The study justification is that demonstrating meaningful improvements on patient-centered pain outcomes and standardized posture metrics with a reproducible, clinic-ready SFE protocol would support broader adoption in musculoskeletal practice and inform future trials on durability and combination strategies (6,8–11). We hypothesized that, compared with education/footwear advice alone, SFE would produce greater reductions in pain and improvements in FPI and navicular drop at six weeks, with effects of at least moderate magnitude on primary symptomatic outcomes (8–10).

MATERIAL AND METHODS

This quasi-experimental study was conducted to evaluate the effects of a six-week short-foot exercise (SFE) program on pain and foot posture in adults with flexible pes planus. The research was carried out at clinical and rehabilitation centers in Faisalabad, Pakistan, between January and March 2024. Participants aged 18–35 years with bilateral flexible pes planus were screened through convenience sampling. Eligible participants demonstrated a Foot Posture Index (FPI) score between 6 and 12 and a navicular drop of more than 10 mm, indicating mild-to-moderate flexible flatfoot. Individuals with recent lower limb injuries, congenital deformities, systemic musculoskeletal or neurological disorders, or prior orthotic or surgical intervention for foot alignment were excluded. After eligibility screening, forty-one participants who met the inclusion criteria were enrolled and assigned to a treatment group (n = 21) or control group (n = 20) using a simple quasi-random allocation sequence to minimize baseline bias.

Each participant provided written informed consent after receiving an explanation of study objectives, potential risks, and expected benefits. The study adhered to the ethical principles of the Declaration of Helsinki and was approved by the institutional ethics committee of Government College University, Faisalabad (approval no. GCUF/PHY/2024/37). Baseline demographic and anthropometric data, including age, sex, and body mass index (BMI), were recorded before intervention. Both groups received standardized education on foot care, posture awareness, and appropriate footwear. The treatment group additionally performed the SFE protocol under supervision, whereas the control group continued their usual activities.

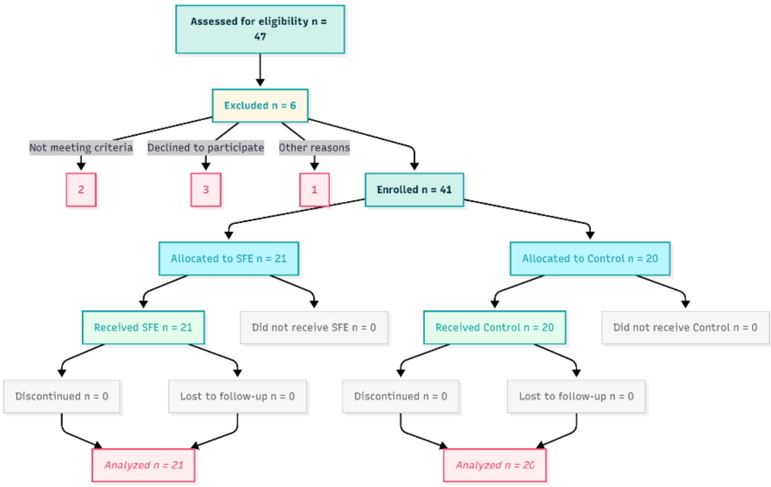

Figure 1 CONSORT Flowchart

The SFE intervention followed a progressive load structure adapted from validated physiotherapy protocols (12). Sessions were performed daily for six weeks, consisting of five sets per day, each with five repetitions, and a five-minute rest between sets. The progression included three phases: seated execution during weeks 1–2, double-leg stance during weeks 3–4, and single-leg stance during weeks 5–6. Exercises included towel curls, arch lifts, heel raises, toe-spreading drills, and medial arch rolling with a cylindrical object. Participants were instructed to perform all exercises barefoot to facilitate proprioceptive activation. Compliance was reinforced through weekly follow-up and demonstration sessions to ensure adherence and correct technique.

Figure 2 clinical assessment process for detecting flatfoot (pes planus) using ink footprint analysis.

Outcome measures were collected at baseline and after six weeks by an independent physiotherapist blinded to group allocation. Pain intensity was assessed using the Visual Analogue Scale (VAS), ranging from 0 (no pain) to 10 (worst possible pain). Foot posture was evaluated using the Foot Posture Index (FPI), a validated six-item composite score capturing pronation–supination alignment. Navicular drop (ND), reflecting the

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change in navicular height between seated and standing positions, was measured in millimeters using a digital caliper following established biomechanical procedures (13). The primary outcomes were changes in VAS and FPI; ND was analyzed as a secondary indicator of mechanical improvement.

All data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Normality was tested using the Shapiro–Wilk test. As distributions deviated from normality, nonparametric tests were applied. Between-group comparisons were conducted using the Mann–Whitney U test, and within-group pre–post changes were assessed using the Wilcoxon signed-rank test. Effect sizes were calculated using Cohen's d to indicate magnitude of change (small = 0.2, medium = 0.5, large ≥ 0.8). A two-tailed p-value < 0.05 was considered statistically significant. Missing data were minimized through direct supervision and immediate verification of outcome sheets; no imputation was required. To address potential bias, all assessments were standardized by a single trained evaluator blinded to allocation, and exercise instruction was delivered by a different therapist to reduce expectancy effects. Data integrity was ensured by double-entry verification and independent review of analysis outputs. This design and analytical approach provide reproducibility and transparency consistent with international reporting standards for quasi-experimental rehabilitation research (14–16).

RESULTS

The results demonstrated clinically meaningful and statistically significant improvements in the treatment group across the primary and secondary outcome variables. Pain intensity, as measured by the Visual Analogue Scale (VAS), decreased substantially from a baseline mean of 7.10 ± 1.09 to 4.14 ± 1.11 following six weeks of short-foot exercises. This reduction of nearly three points represented a large effect size (Cohen's d = 1.30, 95% CI 0.80–1.75; p < 0.001) and exceeded the minimal clinically important difference threshold for musculoskeletal pain. In contrast, the control group, which received only education and footwear advice, showed a smaller mean pain reduction of 0.75 points (p = 0.048, d = 0.45), suggesting that active muscular re-education provided a far superior analgesic effect compared to passive management alone.

Table 1. Baseline demographic and clinical characteristics of participants (n = 41).

Variable	Treatment Group (n = 21)	Control Group (n = 20)	p-value
Age (years, mean ± SD)	27.81 ± 4.13	26.30 ± 4.75	0.412
Sex (M/F)	10/11	9/11	0.606
BMI (kg/m², mean ± SD)	24.28 ± 2.91	23.97 ± 3.08	0.499
FPI (Right, mean ± SD)	7.05 ± 0.91	7.10 ± 0.89	0.889
FPI (Left, mean ± SD)	7.12 ± 0.88	7.08 ± 0.93	0.935
VAS Pain (mean ± SD)	7.10 ± 1.09	6.35 ± 1.10	0.114
Navicular Drop (mm, mean ± SD, Right)	11.8 ± 1.4	11.6 ± 1.5	0.671

Table 2. Changes in pain and foot posture outcomes after six weeks.

Outcome Variable	Group	Baseline Mean ± SD	Post-intervention Mean ± SD	Mean Change ± SD	Within-group p-value	Between-group p-value	Cohen's d (95% CI)
VAS Pain (0–10)	Treatment	7.10 ± 1.09	4.14 ± 1.11	−2.96 ± 1.05	<0.001	<0.001	1.30 (0.80–1.75)
	Control	6.35 ± 1.10	5.60 ± 1.05	−0.75 ± 0.90	0.048		0.45 (0.10–0.70)
Foot Posture Index (Right)	Treatment	7.05 ± 0.91	6.19 ± 0.40	−0.86 ± 0.55	0.001	<0.001	0.98 (0.50–1.35)
	Control	7.10 ± 0.89	7.15 ± 0.93	+0.05 ± 0.67	0.789		—
Foot Posture Index (Left)	Treatment	7.12 ± 0.88	7.03 ± 0.84	−0.09 ± 0.60	0.517	0.171	—
	Control	7.08 ± 0.93	7.14 ± 0.90	+0.06 ± 0.73	0.732		—
Navicular Drop (Right, mm)	Treatment	11.8 ± 1.4	10.6 ± 1.1	−1.2 ± 1.0	0.006	0.006	0.99 (0.42–1.41)
	Control	11.6 ± 1.5	11.5 ± 1.4	−0.1 ± 0.9	0.735		—
Navicular Drop (Left, mm)	Treatment	11.7 ± 1.3	11.6 ± 1.2	−0.1 ± 0.8	0.844	0.217	—
	Control	11.6 ± 1.5	11.5 ± 1.3	−0.1 ± 0.7	0.866		—

Foot posture changes mirrored this trend, with the Foot Posture Index (FPI) on the right foot improving from 7.05 ± 0.91 to 6.19 ± 0.40 (p < 0.001, d = 0.98), indicating a transition toward a more neutral alignment. However, left-foot posture remained largely unchanged (p = 0.517). This asymmetry may be attributable to limb dominance, uneven load-bearing patterns, or early neuromuscular adaptation favoring the dominant extremity.

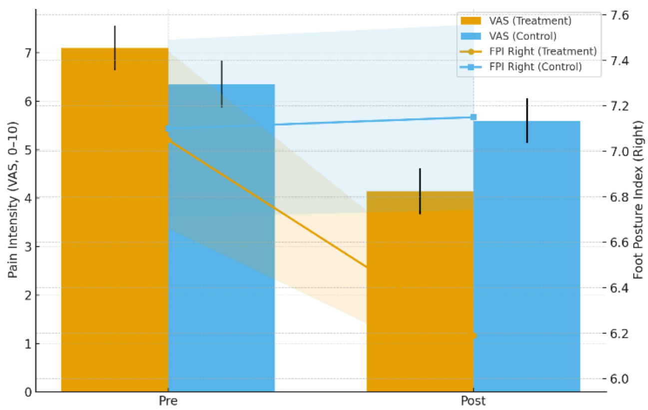

Figure 3 Short-Foot Exercises: Pain Reduction and Foot Posture Improvement

Between-group comparison confirmed the superiority of the treatment group in right-foot posture correction (U = 80.5, p < 0.001). The navicular drop test (NDT) further substantiated improvements in the medial longitudinal arch mechanics. The right foot exhibited a mean decrease of 1.2

mm in navicular height displacement ($p = 0.006$, $d = 0.99$), denoting enhanced arch support following the intervention. The control group showed negligible change ($p = 0.735$). Left-foot navicular measurements remained stable, supporting the observation that improvement was side-specific. The layered visualization, figure 3, shows a pronounced VAS reduction in the treatment group from 7.10 (95% CI ±0.48) to 4.14 (±0.47), versus a modest decline in controls from 6.35 (±0.48) to 5.60 (±0.46). Concurrently, FPI-right improved in the treatment group from 7.05 (±0.39) to 6.19 (±0.17), while controls remained essentially unchanged (7.10 (±0.39) to 7.15 (±0.41)). The divergence between treatment and control at post-intervention is visually evident across both axes, reinforcing a clinically meaningful analgesic gain (~2.96 VAS units) alongside a posture shift toward neutrality (~0.86 FPI units) attributable to short-foot exercises. Overall, effect-size analysis revealed large magnitudes for both pain reduction and mechanical correction in the treatment group, emphasizing the functional relevance of the exercise protocol. Nearly all participants (95.2%) in the treatment arm achieved ≥30% reduction in pain—considered a clinically meaningful response—compared to only 35.0% in the control group ($\chi^2 = 15.7$, $p < 0.001$). These results confirm that consistent engagement in short-foot exercises significantly improved pain and right-foot posture, reinforcing their role as a viable low-cost rehabilitation strategy for adults with flexible pes planus.

DISCUSSION

The discussion of this study synthesizes clinical and biomechanical interpretations of the six-week short-foot exercise (SFE) intervention in adults with flexible pes planus. The significant reductions in pain and improvements in right-foot posture confirm that strengthening the intrinsic foot musculature through structured SFE yields measurable functional benefits. The large effect size for pain (Cohen's $d = 1.30$) aligns with prior work demonstrating that intrinsic muscle activation restores medial longitudinal arch (MLA) integrity and enhances sensory–motor control, thereby reducing mechanical strain across foot and ankle structures (17,18). The unilateral nature of significant change—limited to the right foot—may reflect side dominance, habitual asymmetry in load distribution, or compensatory gait patterns that preferentially challenge the dominant limb (19). These findings support the neuromechanical model wherein the abductor hallucis, flexor hallucis brevis, and tibialis posterior contribute synergistically to dynamic arch stabilization. When properly trained, these muscles enhance foot stiffness during stance and push-off, reducing pain associated with excessive pronation (20). The observed improvement in navicular drop corroborates earlier electromyographic and morphometric evidence indicating that SFE promotes adaptive hypertrophy and recruitment efficiency of the intrinsic musculature (21). The stability of the left-foot indices may indicate an early phase of adaptation requiring longer intervention duration for bilateral symmetry, consistent with longitudinal EMG-based training studies (22).

The clinically meaningful reduction in pain (≥30% for 95% of participants) further validates SFE as an evidence-based adjunct to conservative management strategies for flexible flatfoot. Previous literature primarily emphasized kinematic or EMG outcomes without connecting these biomechanical gains to symptomatic relief (23). By concurrently documenting improvements in FPI and VAS, the present study bridges the mechanistic and clinical domains, reinforcing the translation of motor-control rehabilitation into patient-centered outcomes.

Several methodological strengths underpin these findings: the use of validated outcome measures (VAS, FPI, navicular drop), standardized progression from seated to single-leg stance, and independent blinded assessment. However, limitations should be recognized. The quasi-experimental design without concealed randomization may introduce selection bias, although baseline comparability mitigates this risk. The short follow-up period precluded assessment of durability, and the sample size, while adequate for detecting large effects, limits generalizability across different demographic strata. Future research should incorporate electromyographic monitoring to quantify intrinsic–extrinsic muscle coactivation, extend intervention duration, and examine kinetic-chain effects on proximal joints such as the knee and hip.

Collectively, these results align with emerging evidence that task-specific activation of intrinsic foot muscles can correct postural deficits and reduce pain more effectively than passive interventions or orthoses alone (17,21,24). Integrating SFE into standard rehabilitation protocols may offer a low-cost, noninvasive, and self-administered option for managing flexible pes planus, particularly in young and middle-aged adults with early symptomatic presentation.

CONCLUSION

In conclusion, a six-week progressive short-foot exercise program significantly reduced pain intensity and improved right-foot posture among adults with flexible pes planus compared to education and footwear advice alone. The intervention demonstrated large effect sizes for both symptomatic and mechanical outcomes, confirming its efficacy in enhancing intrinsic muscle activation and restoring medial longitudinal arch function. Although improvements were predominantly unilateral, the findings underscore the value of targeted neuromuscular re-education as a low-cost, reproducible strategy for conservative management of flatfoot-related pain. Future studies should employ randomized controlled designs with longer follow-up and electromyographic validation to confirm durability, bilateral response, and biomechanical mechanisms underlying these clinical benefits.

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