

Association of Abnormal Foot Posture with Low Back Pain Severity and Functional Disability among University Students: A Cross-Sectional Study

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ABSTRACT

Background: Variations in foot posture may influence lower-extremity biomechanics, but their relationship with low back pain in young university populations remains uncertain. **Objective:** To estimate the frequency of high-arched, pes-cavus-compatible foot posture and low back pain and examine the association between overall foot-posture category and low back pain intensity among university students. **Methods:** An analytical cross-sectional study included 119 students recruited by convenience sampling at the University of Lahore. Foot posture was classified using the six-item Foot Posture Index (FPI-6), and low back pain was measured using the Numeric Pain Rating Scale (NPRS). Descriptive statistics, Wilson 95% confidence intervals, Pearson chi-square statistics, and Cramér's V were used. **Results:** Participants had a mean age of 22.02 ± 2.66 years, and 66 (55.5%) were female. Supinated or highly supinated posture was observed in 39 students (32.8%; 95% CI 25.0%–41.6%), while 73 (61.3%; 95% CI 52.4%–69.6%) reported low back pain. Mild, moderate, and severe pain affected 36 (30.3%), 23 (19.3%), and 14 (11.8%), respectively. The omnibus FPI-6–NPRS comparison yielded $\chi^2(12)=199.407$, asymptotic $p<0.001$, and Cramér's $V=0.747$; however, 10 of 20 expected cell counts were below five. **Conclusion:** Abnormal foot-posture categories and low back pain were frequent in this sample. The observed omnibus association requires cautious interpretation and does not establish a specific association between pes cavus and low back pain. **Keywords:** Pes cavus; Foot Posture Index; Low back pain; University students; Cross-sectional study.

INTRODUCTION

The foot forms an important component of the lower-extremity kinetic chain, contributing to weight distribution, shock attenuation, postural stability, and the transmission of forces during standing and locomotion. Foot posture varies along a continuum from supination to pronation, and its clinical characterization requires a reproducible measure rather than visual assessment of arch height alone. The six-item Foot Posture Index (FPI-6) was developed as a standardized observational instrument for assessing standing foot posture; normative research subsequently described the distribution of FPI scores across populations (1,2).

Abnormal foot posture can be encountered during childhood and early adulthood. Khan et al. documented pes planus and associated foot-health outcomes among university students (3), while Qasim et al. identified both pes planus and pes cavus among school-going children (4). Paecharoen and Kritsanapraneet also reported differences in foot-arch type and associated symptoms among medical students (5). These findings indicate that variation in foot structure is relevant across educational-age populations, although prevalence estimates depend on the measurement method and diagnostic classification used.

Pes cavus is generally characterized by an elevated medial longitudinal arch and is often accompanied by a relatively rigid foot configuration. Such morphology may alter plantar loading, the capacity of the foot to accommodate ground reaction forces, and compensatory movement along the lower-extremity kinetic chain. Foot problems have been associated with balance, physical activity, and musculoskeletal pain (6), and young-adult research has linked foot and knee postural alterations with anthropometric and physical-activity characteristics (7). Nevertheless, a biomechanical explanation for an observed association should not be mistaken for a causal mechanism demonstrated in a cross-sectional sample.

Low back pain is a substantial musculoskeletal concern in university populations. Prolonged sitting, academic activity, physical inactivity, and other personal or environmental factors may contribute to symptoms, although the relative contribution of these exposures differs between settings. A 2024 cross-sectional study among medical students reported a considerable burden of low back pain and investigated associated factors (8). Because low back pain is multifactorial, foot posture should be considered as one possible correlate rather than a sufficient explanation for lumbar symptoms.

Prior observational studies suggest that structural or functional foot characteristics may be related to lumbar symptoms. Almutairi et al. examined low back pain among people with flat feet (9), while Ayuningtiyas et al. explored the relationship between the medial longitudinal arch and lower-back disability among dancers (10). Moradi et al. investigated podiatric deviations in relation to nonspecific chronic low back pain (11), and Dasgupta et al. studied the correlation between foot arches and low back pain in an Indian population (12). A systematic review has also considered links between podiatric deviations and nonspecific chronic low back pain, while emphasizing limitations in the available evidence (13). Findings from pes planus or clinically symptomatic populations cannot automatically be extended to pes cavus among university students.

The FPI-6 has also been examined for reliability and validity in individuals with low back pain (14). However, the relationships between distinct foot-posture categories, pain presence, and pain intensity remain insufficiently characterized in many young university populations. In particular, supinated FPI categories are not equivalent to a definitive structural diagnosis of pes cavus, a distinction that must be retained when interpreting screening-based research. The present study therefore aimed to estimate the frequency of supinated and highly supinated foot posture and low back pain among university students and to examine the association between overall FPI-6 category and low back pain intensity. The prespecified clinical interest was the possible relationship between high-arched foot posture and low back pain.

MATERIALS AND METHODS

An analytical cross-sectional study was conducted at the University of Lahore, Lahore, Pakistan, over a six-month period following approval of the study synopsis. The study examined the distribution of foot-posture categories and low back pain intensity within a university sample, with particular interest in the occurrence of supinated and highly supinated foot posture.

The target population comprised university students aged 18–30 years. Students who met the study eligibility criteria and consented to participate were recruited through non-probability convenience sampling. A total of 119 students were included. The required sample size had been estimated using OpenEpi, version 3, with reference to prevalence findings from a comparable university population. Students were approached within the study setting, informed about the study purpose and assessment procedures, and enrolled after providing informed consent.

Information was collected using a demographic form, the FPI-6, and the Numeric Pain Rating Scale (NPRS). The demographic form recorded age, sex, and academic level. Foot posture was assessed with the FPI-6, an observational measure that considers six clinical features of foot alignment in standing (1,2). The categories used in the study were normal, pronated, highly pronated, supinated, and highly supinated. For the study's operational definition, the latter two categories were combined as a high-arched or pes-cavus-compatible posture group. This classification identifies a clinical foot-posture pattern rather than confirming structural pes cavus by imaging or other anatomical investigation.

Low back pain intensity was assessed using the NPRS, with scores ranging from 0 (no pain) to 10 (maximum pain intensity). Numerical pain-rating instruments are widely employed for self-reported pain intensity in adult clinical and research settings (15). For the present categorical analysis, an NPRS score of 0 denoted no pain, scores of 1–3 mild pain, 4–6 moderate pain, and 7–10 severe pain. Any non-zero score was classified as low back pain for the descriptive prevalence estimate. The same measurement and categorization framework was used for the study participants.

The principal explanatory measure was FPI-6 foot-posture category, with supinated and highly supinated categories of special clinical interest. The principal reported outcome was low back pain intensity, examined both as presence or absence of pain and as an ordered four-level intensity category. Descriptive and categorical analyses were performed using IBM SPSS Statistics version 26.0. Age was summarized as the mean, standard deviation, and observed range; categorical variables were summarized as frequencies and percentages. Prevalence estimates were expressed relative to the full sample of 119 participants, and 95% Wilson confidence intervals were calculated for the overall estimates of high-arched foot posture and any low back pain.

The original overall comparison of the five FPI-6 categories against the four NPRS categories used Pearson's chi-square statistic, with a nominal two-sided significance level of 0.05. Cramér's V was used to quantify the magnitude of the omnibus categorical association. Expected frequencies were evaluated from the reported marginal totals to assess the appropriateness of the asymptotic chi-square approximation. The overall test compares the complete foot-posture distribution and does not estimate the association specifically attributable to the high-arched group.

Ethical approval was obtained before data collection. Participation was voluntary, and informed consent was obtained before assessment. Participant information was collected for the study and handled in accordance with the approved study protocol.

RESULTS

The analysis included 119 university students. The mean age was 22.02 ± 2.66 years (range 18–27). Of the participants, 66 (55.5%) were female and 53 (44.5%) were male. Undergraduate students constituted 96 (80.7%) of the sample, with the remaining 23 (19.3%) enrolled in postgraduate study (Table 1).

Table 1. Demographic characteristics of the participants (n = 119)

Characteristic	Value
Age, years (mean $\pm$ SD)	22.02 $\pm$ 2.66
Age, years (range)	18–27
Male, n (%)	53 (44.5)
Female, n (%)	66 (55.5)
Undergraduate, n (%)	96 (80.7)
Postgraduate, n (%)	23 (19.3)

SD, standard deviation.

Foot-posture classifications varied across the sample (Table 2). Normal posture was observed in 7 (5.9%) participants, pronated posture in 17 (14.3%), and highly pronated posture in 56 (47.1%). Supinated posture was found in 18 (15.1%) participants and highly supinated posture in 21 (17.6%). The combined high-arched or pes-cavus-compatible group therefore included 39 of 119 students, equivalent to 32.8% (95% CI 25.0%–41.6%). In comparison, the combined pronated and highly pronated groups included 73 (61.3%) participants.

Table 2. FPI-6 foot-posture categories (n = 119)

FPI-6 classification	n (%)
Normal	7 (5.9)
Pronated	17 (14.3)
Highly pronated	56 (47.1)
Supinated	18 (15.1)
Highly supinated	21 (17.6)
Supinated or highly supinated (combined)	39 (32.8)

The combined row is a derived summary and is not an additional mutually exclusive category. For the combined group, the Wilson 95% CI was 25.0%–41.6%.

Table 3. Numeric Pain Rating Scale categories (n = 119)

NPRS category	n (%)
No pain (0)	46 (38.7)
Mild pain (1–3)	36 (30.3)
Moderate pain (4–6)	23 (19.3)
Severe pain (7–10)	14 (11.8)
Any low back pain (1–10)	73 (61.3)
Moderate-to-severe pain (4–10)	37 (31.1)

The final two rows are derived summaries rather than additional mutually exclusive categories. For any low back pain, the Wilson 95% CI was 52.4%–69.6%.

A total of 73 (61.3%) participants had an NPRS score above zero, yielding an estimated frequency of low back pain of 61.3% (95% CI 52.4%–69.6%). Pain was absent at 46 (38.7%), mild in 36 (30.3%), moderate in 23 (19.3%), and severe in 14 (11.8%) participants (Table 3). Moderate-to-severe pain was recorded in 37 (31.1%) participants, representing 50.7% of those reporting any low back pain.

The five-category FPI-6 by four-category NPRS comparison yielded a Pearson chi-square statistic of 199.407 with 12 degrees of freedom, an asymptotic p value below 0.001, and Cramér's V of 0.747 (Table 4). The marginal distributions imply that 10 of the 20 expected cell frequencies (50.0%) were below five, including a minimum expected count of 0.82. Consequently, the asymptotic p value is exploratory and does not provide a methodologically secure confirmatory test without a sparse-cell-appropriate analysis. Furthermore, the omnibus effect-size estimate cannot establish a separate association between pes-cavus-compatible posture and low back pain, because the underlying participant-level cross-tabulation is required for that comparison.

Table 4. Omnibus association between FPI-6 category and NPRS intensity category (n = 119)

Analysis	Pearson χ^2	df	Asymptotic p	Cramér's V
FPI-6 (5 levels) × NPRS (4 levels)	199.407	12	<0.001	0.747

Expected cell counts calculated from the marginal totals: 10/20 below five; minimum 0.82. The asymptotic p value is not confirmatory under this degree of sparsity. Cramér's V = $\sqrt{[\chi^2/(119 \times 3)]}$.

Observed foot-posture and pain-intensity distributions (n = 119)

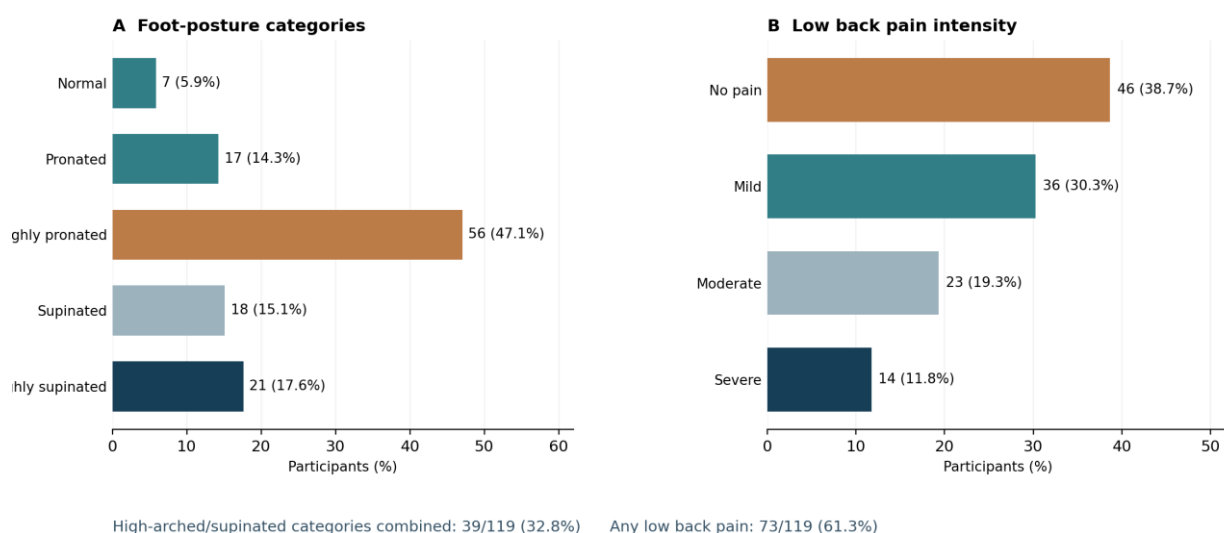


Figure 1. Distribution of foot-posture and low back pain categories.

Figure 1 illustrates the distribution of foot-posture categories and low back pain intensity among 119 university students. Highly pronated foot posture was the most prevalent category, observed in 56 participants (47.1%), followed by highly supinated posture in 21 (17.6%), supinated posture in 18 (15.1%), pronated posture in 17 (14.3%), and normal foot posture in 7 (5.9%). The combined prevalence of supinated and highly supinated foot posture, classified as pes cavus, was 32.8% (39/119). Regarding low back pain intensity, 46 participants (38.7%) reported no pain, whereas 36 (30.3%) experienced mild pain, 23 (19.3%) moderate pain, and 14 (11.8%) severe pain. Overall, 73 participants (61.3%) reported low back pain, including 37 (31.1%) with moderate-to-severe symptoms. These findings demonstrate a substantial prevalence of abnormal foot posture and low back pain within the study population.

DISCUSSION

This analytical cross-sectional study identified a considerable frequency of both abnormal foot-posture classifications and low back pain among students at one university. Approximately one-third were classified within supinated or highly supinated FPI-6 categories, while more than three-fifths reported some degree of lumbar pain. The overall classification of foot posture showed a large exploratory omnibus association with pain-intensity category. However,

that association describes the complete five-category FPI-6 distribution; it cannot be interpreted as evidence that pes cavus itself was associated with greater pain severity.

The observed frequency of high-arched or pes-cavus-compatible posture adds to research documenting foot-structure variation in young populations. Qasim et al. described pes planus and pes cavus among school-going children (4), while Paecharoen and Kritsanapraneet documented arch-type patterns and related symptoms among medical students (5). Khan et al. likewise highlighted the clinical relevance of foot-posture variation in university students, although their principal focus was pes planus and foot-related quality of life (3). Between-study differences are expected because age distributions, sampling methods, measurement tools, thresholds, and anatomical definitions vary. In the present investigation, the operational classification relied on FPI-6 supination rather than a separate structural diagnostic assessment; accordingly, the reported 32.8% should not be compared uncritically with imaging-confirmed pes cavus prevalence.

Low back pain affected 61.3% of the participants under the study's NPRS-based definition. Other university-based investigations have demonstrated that back pain may occur frequently in young adult student populations, although prevalence depends strongly on the recall period and case definition (8). Student activity patterns, time spent sitting, workload, and individual physical or psychosocial factors are potentially relevant, but these exposures were not quantified in the present analysis. The 61.3% estimate therefore represents the proportion reporting a non-zero pain rating under the applied assessment and should not be interpreted as a standardized lifetime, annual, or point-prevalence estimate without a stated recall period.

Research examining foot posture and lumbar pain provides a plausible context for the current observations. Almutairi et al. studied low back pain among individuals with flat feet (9), and Ayuningtiyas et al. assessed the medial longitudinal arch in relation to lower-back disability (10). Dasgupta et al. also explored associations between arch morphology and back pain (12). These studies concern different populations and foot characteristics; their findings therefore support continued investigation of lower-limb and lumbar relationships but do not establish that a highly supinated posture independently predicts pain. A separate investigation of foot-arch types and chronic low back pain in Sri Lankan adults offers additional context for the importance of distinguishing arch categories rather than grouping all non-neutral feet together (16).

From a biomechanical perspective, alterations in foot posture may influence ground-contact mechanics, shock absorption, and the distribution of forces across the lower limb. Research concerning foot problems, balance, and musculoskeletal pain (6), together with evidence on foot- and knee-posture characteristics in young adults (7), suggests that lower-extremity features may be relevant to broader musculoskeletal function. A high medial longitudinal arch may be less adaptable under load, potentially contributing to compensatory motion at the ankle, knee, hip, pelvis, or lumbar spine. Nonetheless, the present study did not measure plantar pressure, gait kinematics, pelvic alignment, spinal loading, or electromyographic activity. These pathways should therefore be regarded as possible mechanisms rather than explanations established by the data.

The magnitude of the omnibus Cramér's V warrants particular care. Although its computed value of 0.747 is large, the associated Pearson test involved a 5×4 table with substantial sparsity. Half of the expected frequencies calculated from the margins were below five, and one was below one. Under these circumstances, an asymptotic chi-square p value may be unreliable. A complete contingency table and a suitable exact or Monte Carlo procedure would provide a more defensible inferential assessment. In addition, a clinically focused comparison of supinated and highly supinated participants with a clearly defined reference group would be necessary to quantify the frequency of pain or its severity within the intended pes-cavus-compatible subgroup. Neither the omnibus statistic nor the separate marginal prevalences can substitute for such comparisons.

A further limitation is confounding. Factors such as body mass index, habitual physical activity, prolonged sitting, footwear, lower-limb alignment, previous musculoskeletal injury, psychological factors, and ergonomics may influence both posture and pain. No adjusted model incorporating these variables was available in the reported results. The single-institution convenience sample also restricts generalizability, and the cross-sectional design does not establish whether a postural pattern preceded, followed, or merely coexisted with back pain. The modest sample and reliance on categorical assessments may further affect precision, particularly in the small normal-foot-posture group ($n=7$).

The study nevertheless contributes descriptive evidence from a young university sample and employed established observational and pain-rating measures. The use of multiple FPI-6 categories helps avoid treating all foot deviations as biologically equivalent; related validation research supports the utility of FPI-6 assessment in populations with low back

pain (14). In clinical practice, foot-posture assessment may form part of a comprehensive musculoskeletal examination when lower-extremity findings are relevant, but it should not replace lumbar assessment or be used to assume that modifying foot posture will reduce pain. Further studies incorporating clear pain recall periods, documented foot-assessment protocols, complete cross-tabulations, potential confounders, and longitudinal follow-up are required to clarify whether high-arched foot posture has an independent relationship with lumbar symptoms.

CONCLUSION

Among 119 university students, 32.8% were classified as having supinated or highly supinated foot posture, and 61.3% recorded a non-zero low back pain rating. The overall FPI-6 classification showed a large exploratory association with NPRS pain-intensity category, although the sparse cross-tabulation limits inferential certainty. The findings do not establish a separate or causal effect of pes cavus on low back pain. Foot posture may be considered alongside other clinical characteristics in a comprehensive musculoskeletal assessment, while further appropriately analysed studies are needed to clarify the relationship.

DECLARATIONS

Authors' Contributions:	Concept: AJ, HA; Design: AJ, HA, AR; Data Collection: AJ, AR; Analysis: AJ, HA; Drafting: AJ, HA, AR.
Ethical Approval:	The institution responsible for ethical review was Riphah International University, Lahore, Pakistan
Informed Consent:	Written informed consent was obtained from all participants before enrolment.
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Data Availability:	De-identified data may be available from the corresponding author on request, subject to participant consent and institutional confidentiality requirements.
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AI Declaration:	Generative AI tools were used solely for language and grammatical refinement. The authors verified the final manuscript and remain fully responsible for its accuracy, integrity, and scientific content.

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