ORIGINAL RESEARCH

ASSOCIATION BETWEEN FLAT FOOT SEVERITY AND LOW BACK PAIN RECURRENCE AMONG PRE-CLINICAL MEDICAL STUDENTS: A CROSS-SECTIONAL STUDY

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Abstract

Background: Low back pain (LBP) affects over 619 million people globally and is highly prevalent among medical students. Flat foot (pes planus), a biomechanical alteration involving the collapse of the medial longitudinal arch, may contribute to spinal stress and LBP recurrence, yet remains underexplored in young adult populations.

Methods: This cross-sectional study involved 67 pre-clinical medical students aged 19–23 years with a history of recurrent LBP in the past year. LBP frequency was assessed using the Nordic Musculoskeletal Questionnaire and Numeric Rating Scale (NRS). Foot arch structure was evaluated via Clarke's Angle, classifying flat foot severity into mild (35°–41°), moderate (30°– 34.9°), and severe (<30°). Data were analysed using Chi-square tests, with significance set at $p < 0.05$.

Results: LBP was reported by 80.6% of participants, with flat foot classified as mild in 43.3%, moderate in 37.3%, and severe in 19.4%. A significant association was found between flat foot severity and LBP recurrence ($p < 0.001$). Students with mild or moderate flat foot had a lower odd of experiencing moderate-frequency LBP compared to those with severe flat foot (OR = 0.152 95% CI: 0.048–0.483).

Discussion: These findings support the notion that structural abnormalities of the foot, particularly flat foot, may contribute to the recurrence and persistence of LBP by influencing spinal posture, altering mechanical load distribution, and affecting neuromuscular stability.

Conclusion: Flat foot severity is significantly associated with the recurrence of LBP in medical students. Early identification and foot posture assessment may help inform preventive and corrective interventions for recurrent LBP.

Keywords: Low back pain, Flat foot, Clarke's Angle, Medical students, Recurrence, Flat foot severity

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Introduction

Low back pain (LBP) is defined as pain or discomfort located below the costal margin and above the inferior gluteal folds, with or without leg symptoms, and is often associated with limited mobility and functional impairment[1]. Globally, LBP remains the leading cause of years lived

with disability (YLDs), affecting over 619 million individuals as of 2020, with the number projected to reach 843 million by 2050[2,3]. In Indonesia, the situation is similarly concerning. A large-scale study reported a 12-month prevalence of LBP of 44.29% among middle-aged adults, making it one of the most common musculoskeletal complaints[4].

Among university students, especially those in medical education, the burden of LBP is particularly notable. The prevalence of LBP among medical students ranges from 46.9% to 82% in various studies[5–7]. A study conducted at the Faculty of Medicine, Universitas Pelita Harapan, reported a prevalence of 76% among pre-clinical students, highlighting the significance of this condition in young, sedentary, and academically burdened populations[8].

LBP in students can lead to absenteeism, decreased academic performance, poor sleep quality, and early-onset musculoskeletal dysfunctions. While known risk factors such as aging, obesity, poor ergonomics, inactivity or sedentary lifestyle, and work overload are well-established[9–12]. However, flat foot remains an underexplored biomechanical contributor. Pes planus is characterized by the flattening of the medial longitudinal arch, causing altered lower limb alignment and increased lumbar stress[13]. Previous studies by Lulupoy et al. and Kosashvili et al. reported a significant association between flat foot and increased LBP risk[14,15].

Flat foot can be objectively assessed using Clarke's Angle, a non-invasive and reliable method based on static footprint analysis. This approach provides a simple yet validated means to classify foot arch collapse[16]. Despite its clinical utility, limited research has examined flat foot severity as a potential risk for frequent or repeated episodes of LBP among medical students. Most existing data originate from clinical or geriatric populations, and therefore may not be generalizable to young, active adults[14,15]. This study addresses that gap by investigating the relationship between flat foot severity and the recurrence of LBP among pre-clinical medical students. The findings are expected to provide insight into underrecognized biomechanical contributors and support targeted preventive strategies for musculoskeletal health in student populations.

Methods

This cross-sectional analytical study involved 67 pre-clinical medical students from the Faculty of Medicine, Universitas Pelita Harapan, and was conducted between February and April 2025. Participants were selected using purposive sampling based on inclusion criteria: age between 19 and 23 years and a history of recurrent LBP within the past twelve months. Exclusion criteria included obesity (BMI ≥ 30 kg/m²), scoliosis, spinal trauma or surgery, congenital spinal abnormalities, and neurologic conditions that could affect spinal or gait biomechanics.

After obtaining written informed consent, participants completed a structured questionnaire capturing demographic characteristics (age, sex) and clinical data related to LBP, using the Standardized Nordic Musculoskeletal Questionnaire (NMQ). This instrument has been validated by Chareani et al.,

demonstrated excellent reliability (Cronbach's Alpha > 0.945) and 100% construct validity agreement, with specificity exceeding 85% in the lower back, neck, and shoulder regions, making it a valid and reliable tool for assessing musculoskeletal complaints in Indonesian populations[17]. LBP recurrence was categorized into three groups: low-frequency recurrence (<1 episode/month), moderate-frequency recurrence (approximately 1 episode/month), and high-frequency recurrence (>1 episode/month). Pain intensity was assessed using the Numeric Rating Scale (NRS) and classified as mild (1–3), moderate (4–6), or severe (7–10). Ratings were recorded both at rest and during forward trunk flexion. Participants also reported additional symptoms, such as radiation of pain to the lower extremities.

Assessment of foot arch structure was performed using Clarke's Angle (CA), obtained through static footprint analysis. Each participant was instructed to step onto a water-soluble ink pad and then place their foot firmly on a labelled sheet of drawing paper for approximately ten seconds. This process was repeated until a clear and complete footprint was obtained. Using a ruler, pen, and a stainless-steel protractor, the Clarke's Angle was measured as the angle formed between a line drawn along the medial border of the footprint and a second line connecting the deepest point of the medial longitudinal arch to the medial forefoot. Based on this angle, foot arch type was categorized into: mild pes planus (35°–41°), moderate pes planus (30°–34.9°), and severe pes planus (<30°)[18].

Statistical Analysis

IBM's Statistical Package for the Social Sciences (SPSS) version 26 was used to manage and analyze all collected data. Descriptive analysis was conducted for demographic variables and clinical characteristics, including gender, age, flat foot severity (based on Clarke's Angle), recurrence frequency, and pain intensity. Bivariate analysis was performed to examine the association between flat foot severity and the recurrence of LBP.

Categorical variables, including LBP recurrence frequency and pain severity, were analyzed using the Chi-square test or continuity correction test, depending on expected cell counts. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to determine the strength and precision of associations. All statistical tests were two-tailed, and results were considered statistically significant at $p < 0.05$.

Ethical Statement

This study was declared to have passed the ethical review by the Faculty of Medicine, Universitas Pelita Harapan, by obtaining ethics number 125/K-LKJ/ETIK/II/2025. All participants provided written informed consent prior to enrollment, following a clear explanation of the study's objectives, procedures, and potential benefits. Participation was entirely voluntary and based on full understanding of the research purpose.

Results

A total of 120 pre-clinical medical students from the Faculty of Medicine,

Universitas Pelita Harapan were initially recruited for this study. Following the screening process, 22 students were excluded due to obesity (BMI ≥ 30 kg/m²), 15 due to a history of spinal disorders such as scoliosis, lordosis, or spondylitis, and 16 due to a prior history of back trauma. As a result, 67 participants met the inclusion criteria and were included in the final analysis.

Table 1 summarizes the univariable characteristics of the study population. Most participants were female (73.1%) and predominantly aged 20–21 years (71.6%). Based on Clarke's Angle, 43.3% had mild flat foot, 37.3% had moderate, and 19.4% had severe flat foot. The prevalence of LBP was high, with 80.6% of respondents reporting pain in the past year. Low- frequency LBP was reported by 59.7% of participants, while 40.3% experienced moderate frequency, and none reported high-frequency episodes. Among those with LBP, the majority experienced moderate pain intensity (68.5%), and 44.4% reported radiation of pain to the lower limbs.

Table 2 shows the association between flat foot severity, measured using Clarke's Angle, and the frequency of LBP recurrence among pre-clinical medical students. Among those with mild flat foot (35°–41°), 35.8% experienced low-frequency recurrence (<1 episode/month), while only 7.5% reported moderate-frequency recurrence (≈1 episode/month). Conversely, in the moderate- to-severe flat foot group (≤34.9°), 32.8% experienced moderate-frequency recurrence, and 23.9% reported low-frequency recurrence. Statistical analysis revealed a significant association between flat foot severity and LBP recurrence frequency ($p < 0.001$), with an odds ratio of 0.152 (95% CI: 0.048–0.483), indicating that students with mild flat foot had significantly lower odds of experiencing moderate-frequency LBP compared to those with more severe deformities.

Table 1. Univariable Characteristics of Pre-Clinical Medical Students (n = 67)

Characteristic	Categories	n (%)
Age Group (years)	19	12 (17.9)
	20	27 (40.3)
	21	21 (31.3)
	≥ 22	7 (10.5)
Gender	Male	18 (26.9)
	Female	49 (73.1)
Flat Foot Severity (Clarke's Angle)	Mild (35°–41°)	29 (43.3)
	Moderate (30°-34,9°)	25 (37.3)
	Severe (<30°)	13 (19.4)
Reported Low Back Pain (LBP)	Yes	54 (80.6)
	No	13 (19.4)
LBP Intensity (Numeric Rating Scale)	Mild (1 – 3)	17 (31.5)
	Moderate (4 – 6)	37 (68.5)
	Severe (7 – 10)	0 (0.0)
	Low-Frequency (<1x/month)	40 (59.7)
	Moderate-Frequency (~1x/month)	27 (40.3)
	High-Frequency (>1x/month)	0 (0.0)
Pain Radiation to Lower Limbs	Yes	24 (44.4)
	No	30 (55.6)

Table 2. Association Between Flat Foot Severity and Frequency of Low Back Pain Recurrence in Pre-Clinical Medical Students

Subject characteristics	LBP Recurrence		P value	OR [95% CI]
	Low-frequency (<1x/month)	Moderate-frequency (<1x/month)		
Flat Foot Severity (Clarkes's Angle)				
Mild (35°–41°)	24 (35.8%)	5 (7.5%)	<0.001	0.152
Moderate – Severe (≤34,9°)	16 (23.9%)	22 (32.8%)		(0.048–0.483)

Discussion

LBP constitutes a substantial contributor to the global burden of musculoskeletal disorders, particularly

among university populations[19,20]. Medical students are uniquely predisposed to LBP due to prolonged sedentary behaviors, academic stress, disrupted sleep cycles, and insufficient ergonomic awareness during pre-clinical training years. Multiple studies have reported LBP prevalence rates exceeding 70% in this demographic[6–8,12].

In the present study, we observed that 80.6% of pre-clinical medical students experienced LBP within the preceding year. Univariable analysis revealed a predominantly female cohort (73.1%), with most participants aged between 20–21 years (71.6%). This sex disparity is consistent with prior literature, as reported by Vujcic et al., who found that both lifetime and 12- month prevalence rates of LBP were significantly higher among female medical students, with contributing factors including mental stress, prolonged sitting, fatigue, and poor posture[21]**.** Similarly, Smith et al. observed that female students reported LBP 1.8 times more frequently than their male counterparts, underscoring the influence of sex-related biomechanical and psychosocial variables[21]. Notably, this pattern of increased prevalence in females has also been observed in younger populations; a large cross-sectional study by Yao et al. involving over 2000 Chinese schoolchildren aged 10–18 years revealed a significantly higher 3-month LBP prevalence among girls (33.1%) compared to boys (24.7%), with greater frequency, radiating symptoms, and functional impact, thereby suggesting that sex-based differences in LBP manifestation may emerge early and persist into adulthood[22].

Additionally, the severity of flat foot based on Clarke's Angle showed a notable distribution: 43.3% had mild flat foot, 37.3% moderate, and 19.4% severe. The link between flat foot and LBP can be explained biomechanically. A decreased medial longitudinal arch alters the biomechanics of the lower extremities, leading to excessive foot pronation and internal tibial rotation. These changes may cause compensatory pelvic tilt, lumbar hyperlordosis, and increased axial loading on spinal structures. Over time, such postural adaptations can result in paraspinal muscle fatigue, facet joint irritation, and intervertebral disc stress—factors that contribute to recurrent episodes of LBP[23–25].

Our bivariate analysis demonstrated a robust and statistically significant association between increased severity of flat foot and higher frequency of LBP recurrence ($p < 0.001$). Specifically, among participants with mild flat foot (Clarke's angle 35°–41°), only 7.5% reported moderate-frequency recurrence (approximately once per month), compared to 32.8% of those with moderate to severe deformity (≤34.9°). The calculated odds ratio of 0.152 (95% CI: 0.048–0.483) indicates that students with mild flat foot were approximately seven times less likely to experience recurrent LBP than their counterparts with more pronounced arch collapse.

These findings are in accordance with previous studies which have implicated flat foot as a modifiable extrinsic risk factor for spinal discomfort and dysfunction. Godaria et al. further substantiated this association, demonstrating that foot posture, along with working posture, significantly correlated with LBP among workers engaged in prolonged standing

occupations, whereas other factors such as repetition, core strength, and flexibility showed no significant relationship[26]. In a large-scale epidemiological study, Almutairi et al. reported that individuals with flat feet had markedly higher prevalence of both acute (51.6%) and chronic LBP (48.4%), with flat foot increasing the odds of acute and chronic LBP by 3.28 and 4.5 times, respectively[27]. Amoozadeh et al., using the navicular drop test in a case-control design, identified a significant relationship between decreased medial longitudinal arch and the presence of chronic mechanical LBP, highlighting the role of altered foot mechanics in disrupting postural alignment and gait stability, thereby contributing to spinal loading and discomfort[28]. Moezy et al. conducted a case- control study involving 242 subjects, using the Helbing sign and Navicular Drop Test to assess foot overpronation, and found significant associations with LBP intensity, duration, and reduced ankle dorsiflexion ($p = 0.001$)[29]. These results support the kinetic chain theory linking foot posture to spinal load. Likewise, Lulupoy et al. used Clarke's angle (≤30°) in a case-control design and showed that flat foot increased the risk of mechanical LBP by over six times (OR: 6.29; $p < 0.001$)[14]. Cumulatively, the evidence supports the notion that structural abnormalities of the foot, particularly flat foot, may contribute to the recurrence and persistence of LBP by influencing spinal posture, altering mechanical load distribution, and affecting the stability of neuromuscular function.

While our study offers valuable insight into a relatively underexplored etiological factor among medical students, several methodological limitations must be acknowledged. The cross-sectional design precludes causal inference and limits temporal analysis. Self-reported measures of LBP frequency may also be subject to recall or reporting bias. Additionally, Clarke's Angle, while widely used, may not fully capture the dynamic aspects of foot biomechanics. Future studies should incorporate gait analysis and longer follow-up to assess the impact of flat foot correction (e.g., orthotics) on LBP outcomes.

Conclusion

In conclusion, this study demonstrates a significant association between the severity of flat foot and increased recurrence of LBP among pre-clinical medical students. Biomechanical alterations due to arch collapse likely contribute to compensatory postural changes and spinal stress, reinforcing the relevance of foot posture in musculoskeletal health. Despite methodological limitations, these findings highlight flat foot as a potentially modifiable risk factor for recurrent LBP in young adults.

Conflict of Interest

The authors declared no conflict of interest.

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