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Article

Flat Foot and Its Association with Mechanical Low Back Pain: A Case-Control Study Utilizing Clarke's Angle Measurement

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Abstract:

Background: Mechanical low back pain (MLBP) is a leading cause of disability worldwide, with well-established risk factors such as obesity, occupational ergonomics, and core muscle strength. However, the role of pes planus (flat foot) as a contributing factor remains underrecognized. This study aims to investigate the association between flat foot and MLBP using Clarke's angle as an objective measure of foot posture. **Methods:** A case-control study was conducted in South Timor Tengah Regency, East Nusa Tenggara, Indonesia, from December 2024 to February 2025. Fifty patients diagnosed with MLBP and 50 healthy controls were enrolled. Foot type assessment was performed using Clarke's angle, with a cutoff of ≤30° indicating flat foot. Pain severity in the LBP group was recorded using the Numerical Rating Scale (NRS). Statistical analysis was conducted using chi-square and independent t-tests, with significance set at $p < 0.05$. **Results:** Flat foot was significantly more prevalent in the LBP group (58%) than in the control group (18%) ($p = 0.000$; OR: 6.29, 95% CI: 2.52-15.69), indicating that individuals with flat feet are over six times more likely to experience MLBP. No significant differences were observed between the groups regarding BMI, age, or gender. **Conclusion:** These findings suggest that flat foot is an independent risk factor for MLBP, likely due to altered spinal biomechanics and compensatory postural changes. Clinicians should consider foot posture assessments in MLBP patients and explore targeted interventions, such as orthotic support, to mitigate symptoms.

Keywords: Flat Foot, Pes Planus, Mechanical Low Back Pain, Foot Biomechanics, Clarke's Angle

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1. Introduction

Low back pain (LBP) is a pervasive global health issue, affecting approximately 619 million people worldwide in 2023, with projections suggesting a rise to 843 million cases by 2050 due to ageing populations and sedentary lifestyles [1]. It is estimated that up to 80% of the population will experience at least one episode of LBP in their lifetime, establishing it as a leading cause of disability worldwide [2]. As a common musculoskeletal disorder, LBP is defined as discomfort or pain occurring in the region between the lower rib cage and the gluteal folds, which may or may not radiate to the lower extremities [3]. LBP can be diagnosed as mechanical (nonspecific) or structural (specific/nonmechanical), with mechanical LBP compromising approximately 90% of cases. Mechanical low back pain (MLBP) refers to pain arising from the spinal structures—such as intervertebral discs, vertebrae, ligaments, or facet joints—without an identifiable underlying pathology. In contrast, structural or specific LBP is linked to recognizable conditions, including infection, tumor, osteoporosis, spinal fractures, structural deformities, inflammatory disorders, radicular syndrome, or cauda equina syndrome [4,5].

Despite its benign nature in most cases, MLBP significantly impacts quality of life and functional capacity.

Well-established risk factors for MLBP include obesity, occupational ergonomics, psychosocial parameters, and physical activity, all of which have been extensively documented in the literature [6-8]. However, emerging research suggests that foot posture abnormalities, particularly pes planus (flat foot), may also contribute to its pathogenesis but remain underrecognized [9-11]. Pes planus, defined by a loss of the medial arch, can induce compensatory changes in the lower extremities, pelvis, and lumbar spine, potentially altering spinal biomechanics and increasing susceptibility to pain and injury [12]. Although flexible flat foot is often asymptomatic, dysfunction of the arch complex may contribute to biomechanical instability, thereby influencing lumbar spine mechanics [13].

The association between flat foot and MLBP remains a topic of debate in the scientific literature. Some studies suggest that altered gait mechanics and unphysiological anterior pelvic rotation in individuals with flat foot increase the risk of lumbopelvic dysfunction and pain [14]. Conversely, other research attributes MLBP primarily to factors such as body mass index, core muscle strength, and postural habits, with minimal contribution from foot posture abnormalities. Despite the biomechanical plausibility of this relationship, existing evidence remains limited and inconclusive. Given the high prevalence of both conditions, further investigation is needed to clarify the extent to which flat foot influences lumbar spine mechanics and whether targeted interventions could play a role in MLBP management. This study aims to objectively assess the relationship between flat foot and MLBP in a general adult population using Clarke's angle as a standardized measure of foot posture.

2. Materials and Methods

This analytical observational study utilized a case-control design to examine the association between flat foot and MLBP. The study population consisted of two groups: patients diagnosed with MLBP (cases) and healthy individuals without LBP (controls). Cases were eligible if they were over 18 years of age, had a confirmed diagnosis of MLBP, and were willing to participate. Individuals were excluded if they had a history of trauma or fracture in the spine or lower extremities, spinal deformities, previous spinal surgery, autoimmune conditions (such as rheumatoid arthritis or systemic lupus erythematosus), or herniated disc with radiculopathy. Similarly, controls were recruited from the same source population and met the same age and exclusion criteria, with the additional requirement of having no history of low back pain or significant musculoskeletal disorders.

Data collection took place in South Timor Tengah Regency, East Nusa Tenggara, Indonesia, and involved interviews and clinical examinations conducted consecutively over a three-month period from December 2024 to February 2025. Collected variables included subject demographics (age, weight, height, body mass index (BMI) with corresponding BMI categories, and gender) and foot type assessment. Flat foot was determined using the Clarke angle, with a cutoff value of ≤30° indicating flat foot and >30° signifying a normal foot arch [15]. Measurement of CA were done by asking the patients to step onto a water-soluble ink pad with the affected foot and subsequently press it onto drawing paper, which already contained their identification, for a period of ten seconds. This procedure was repeated until a clear footprint was achieved. The CA was then measured using a pen, ruler, and stainless steel protractor, focusing on the angle formed between the medial sole line and the deepest peak of the medial longitudinal arch.

For the LBP group, additional clinical characteristics were recorded, such as the site and laterality of pain, pain severity measured by the Numerical Rating Scale (NRS), and the duration of pain onset, which was categorized as acute (<6 weeks), subacute (6 weeks to 3 months), or chronic (>3 months).

Statistical analysis was performed using SPSS version 27, with continuous variables described as means with standard deviations and categorical variables presented as frequencies and percentages. The chi-square test was employed to assess associations between categorical variables, while independent t-tests were used for comparisons of continuous variables, with statistical significance set at $p < 0.05$.

3. Results

A total of 100 subjects were enrolled in this study, comprising 50 patients diagnosed with MLBP and 50 healthy controls. The baseline characteristics, including BMI, weight, height, and gender distribution, were comparable between the MLBP and control groups. Foot type assessment revealed that among patients with LBP, 42% had a normal foot arch, while 30% had unilateral flat foot and 28% had bilateral flat foot. In contrast, 82% of controls exhibited a normal foot arch, with only 12% showing unilateral and 6% bilateral flat foot. In the LBP group, the pain was predominantly paravertebral (98%), with only 2% reporting buttock pain. Regarding pain involvement, 22% experienced right-sided pain, 34% left-sided, and 44% bilateral pain. Pain severity was classified as low (NRS 1-3) in 26% of cases and moderate (NRS 4-6) in 74%, with no cases of severe pain (NRS 7-10). The onset of pain was acute (<6 weeks) in 96% of patients and subacute (6 weeks-3 months) in 4%, with no chronic cases reported.

Table 1. Demographic and Clinical Characteristics of the Research Population.

Subjects Characeristics	MLBP (n=50)	Healthy Controls (n=50)	p value
Age	50.92 ± 11.66	46.44 ± 11.23	0.115
Weight	57.86 ± 11.38	56.68 ± 12.09	0.956
Height	157.36 ± 6.79	157.72 ± 7.67	0.226
Gender			0.841
Male	23 (46 %)	22 (44 %)	
Female	27 (64 %)	28 (66 %)	
BMI category			0.754
Underweight	7 (14 %)	11 (22 %)	
Normal	13 (26 %)	13 (26 %)	
Overweight	12 (24 %)	10 (20 %)	
Obese	18 (36 %)	16 (32 %)	
Foot type			
Normal	21 (42 %)	41 (82 %)	
Flat foot unilateral	15 (30 %)	6 (12 %)	
Flat foot bilateral	14 (28 %)	3 (6 %)	
	Clinical characteristics of MLBP		
Site of MLBP			
Buttock	1 (2 %)		
Paravertebra	49 (98%)		
LBP Involvement			
Right	11 (22 %)		
Left	17 (34 %)		
Bilateral	22 (44%)		
Pain severity			
Low (NRS 1-3)	13 (26%)		
Moderate (NRS 4-6)	37 (74%)		
Severe (NRS 7-10)	0 (0%)		
Onset			
Acute (< 6 weeks)	48 (96%)		
Subacute (6 weeks - 3 months)	2 (4 %)		
Chronic (> 3 months)	0 (0%)		

Bivariate analysis demonstrated association of foot type between individuals with and without MLBP. Among healthy controls (n = 50), 41 subjects (82%) had a normal foot arch, while only 9 subjects (18%) exhibited flat foot. In contrast, among patients with low back pain (n = 50), only 21 subjects (42%) had a normal foot arch, and 29 subjects (58%) had flat foot. This difference was statistically significant (p = 0.000) with an odds ratio of 6.29 (95% CI: 2.52-15.69), indicating that subjects with flat foot are over six times more likely to experience MLBP compared to those with a normal foot arch.

Table 2. Association of Foot Type Between Individuals With and Without Mechanical Low Back Pain.

	MLBP (n=50)	Healthy Controls (n=50)	P value	OR [95% CI]
Foot type				
Normal	21 (42%)	41 (82%)	**0.000**	6.29 [2.52 - 15.69]
Flat foot	29 (58%)	9 (18%)		

4. Discussion

Understanding the multifactorial nature of MLBP is crucial for optimizing prevention and management strategies. While spinal and muscular dysfunctions are well-recognized contributors, emerging research highlights the potential role of distal biomechanical factors, particularly foot posture abnormalities. Flat foot has been hypothesized as a risk factor for MLBP due to its impact on lower limb alignment and lumbopelvic biomechanics; however, its clinical significance remains debated. This study seeks to clarify this association by examining the relationship between foot posture and MLBP, with a focus on the underlying biomechanical mechanisms that may contribute to pain development.

This study demonstrated a significant association between flat foot and mechanical low back pain, with a higher prevalence of pes planus in the LBP group (58%) compared to controls (18%). Statistical analysis further revealed that individuals with flat feet were 6.29 times more likely to experience LBP than those with normal foot arches (OR: 6.29; 95% CI: 2.52-15.69). These findings align with previous research by Azar Moezy et al., which identified a significant relationship between foot overpronation and the incidence, intensity, and duration of LBP [11]. Similarly, Dasgupta et al. reported an elevated risk of acute and chronic LBP in individuals with both low and high-arched feet, while Almutairi et al. further supported the association between flat feet and both acute and chronic LBP [16,17]. Additionally, demographic characteristics such as BMI, age, and gender showed no significant differences between the LBP and control groups, reinforcing flat foot as an independent risk factor.

These findings are supported the hypothesis that biomechanical abnormalities in foot posture may influence weight distribution and spinal alignment, increasing mechanical strain on lumbar structures. Several biomechanical mechanisms may underlie this association. First, hyperpronation, a dynamic malalignment characterized by excessive inward rolling of the foot during weight-bearing, can lead to altered lower limb kinematics, affecting the kinetic chain from the foot to the lumbar spine. This excessive pronation may contribute to compensatory changes in the pelvis and lumbar curvature, increasing the risk of spinal strain [18]. Second, gait alterations caused by flat feet may result in compensatory overuse of the paravertebral muscles, as evidenced by the finding that 98% of LBP cases in this study reported pain localized in the paravertebral region. Since the foot serves as the foundation of postural stability, its misalignment can generate excessive load and ground reaction forces redistribution, further stressing spinal structures [17,19,20]. Third, pelvic posture plays a pivotal role in postural alignment, serving as an intermediary between the spinal column and lower extremities. Abnormal foot alignment can induce pelvic tilts and compensatory spinal adjustments, potentially accelerating the progression of LBP [21,22]. Anterior pelvic tilt, frequently observed in individuals with altered foot posture, has been linked to increased lumbar lordosis and facet joint irritation, further exacerbating low back pain [23].

Despite the significant association observed, causal interpretation requires caution due to the cross-sectional study design. First, this design precludes establishing causality, as it is unclear whether flat foot precedes LBP or whether LBP influences gait patterns and foot posture. Secondly, potential confounding variables such as physical activity levels, occupational demands, and postural habits were not controlled, which may have influenced the observed relationship. Furthermore, the study's relatively small sample size (n=100) may limit the generalizability of the results. Clarke’s angle, while commonly used and valid tools, assesses only static foot posture and may not fully capture the dynamic aspects of foot function during locomotion. Future longitudinal studies with larger, more diverse populations are warranted to validate these findings and to explore whether interventions targeting foot biomechanics—such as orthotic support, proprioceptive training, or ergonomic modifications—could serve as effective strategies in LBP prevention and management.

5. Conclusions

In conclusion, the flat foot is a significant biomechanical contributor to MLBP. Clinicians should consider foot posture assessments in patients with LBP, particularly those reporting acute-onset symptoms. Integrating foot-focused interventions into LBP management protocols may offer a proactive approach to reducing the global burden of this debilitating condition.

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