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Original Article

Association between flatfoot and lower limb fatigue during daily activities among university students

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ABSTRACT

Background: Flatfoot is a frequent musculoskeletal problem, caused by the flattening of the medial longitudinal arch of the foot. It may alter lower limb biomechanics and contribute to increased fatigue during daily activities. Objective: The objective of this study is to find the association between flatfoot and the level of lower limb fatigue experienced during daily activities among university students. Methodology: This cross-sectional study aimed to find the association between flatfoot and lower limb fatigue in 126 university students. Flatfoot severity was assessed using the Foot Posture Index-6, while fatigue was measured using the Fatigue Severity Scale. Data were analyzed using SPSS version 27. Results: Overall, 126 University students participated in the study when classified by foot posture 28.6 % had mild flatfoot, 38.1 % had moderate flatfoot and 33.3 % had severe flatfoot. In terms of fatigue, 44.4 % indicated moderate fatigue, 26.2 % indicated severe fatigue, and 29.4 % indicated mild fatigue in the lower limb. A significant relationship between flatfoot and lower limb fatigue was found in the University students (χ^2 = 74.034, df = 4, p = 0.001) through the Chi-square test. Conclusion: Increased flatfoot severity was associated with higher levels of lower limb fatigue. Keywords: Flatfoot, Pes Planus, Fatigue, Foot Posture Index, College Students

INTRODUCTION

Flatfoot, also called pes planus, is a musculoskeletal disorder in which the foot's medial longitudinal arch collapses or drops. It is seen in all age groups and can have a profound effect on the biomechanics of the lower leg. Depending on how the foot behaves when weight-bearing and not weight-bearing, flatfoot may manifest itself as flexible or rigid. Flexible flatfoots are more prevalent in children, adolescents and young adults and are often normal during the growth years. This type causes the arch to look normal when the person is sitting, but to collapse when standing or walking. Rigid flat foot, on the other hand, is flat in all positions and may be related to congenital deformities, neuromuscular disorders, inflammatory diseases, or traumatic conditions. (1)

The foot is a complex structure made up of 26 bones, many ligaments, intrinsic and extrinsic muscles, tendons and joints that work together to provide stability and movement. . Any disruption of the structural integrity of the arch can cause changes to normal biomechanics and impact the alignment of the ankle, knee, hip and spine. Therefore, abnormalities in foot posture can affect the entire kinetic chain and affect functional performance. The medial longitudinal arch is a vital anatomic feature of the foot as it plays an important role in weight distribution, shock absorption and dynamic foot balance. . With flat foot, the loss of the medial longitudinal arch disturbs these functions and changes the way the body moves. This can then lead to a higher strain on the ligaments, tendons, muscles and joints of the lower limb. (2) (3)

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When the arch collapses, the subtalar joint has to accommodate excessive pronation, thus changing the alignment of the tibia and femur. These changes in the biomechanics of walking and standing are common among University students, who are required to walk and stand for many hours during the day, so this could be a major source of lower limb fatigue and discomfort. Human gait is a complex task, involving muscles, joints and the neural control system working interdependently. The foot plays an important role in optimizing gait efficiency both in response to changes in ground surface and in absorbing shock loads during the stance phase. Excessive pronation and collapse of the arch in flatfoot cause an abnormal gait cycle and changes in plantar pressures, causing inefficient force transmission. Research has shown that people with pes planus experience a longer time spent with feet flat on the ground while walking, have reduced push off efficiency and a different walking kinematics from the ankle. (4) (5)

There is a complex relationship between the developments of fatigue in the lower limb to flatfoot, which can have several biomechanical mechanisms. The muscle activation required for compensation is necessary to maintain postural stability and locomotion. This is because this increased demand in muscle creates an increase in energy expenditure and fatigue. Excessive pronation can also lead to increased internal rotation of the tibia and femur, leading to poor movement patterns and overuse of muscles across the lower limb. (6)

The incidence rate of flatfoot varies by populations and age groups. The prevalence of the disorder has been reported to range from 10 percent to 37 percent, depending on the assessment methods and the demographic characteristics of the population studied. . The university students are a vulnerable group due to the high number of academic requirements, physical inactivity, standing for long periods of time during practical classes, and the large number of walks across campus. The following factors of lifestyle can contribute to the development and/or manifestation of flatfoot and its symptoms. (7)

Flat foot in the young adult population is regarded as a minor problem, but its effects on functional performance during daily activities is unclear. Although university students require high amounts of walking, standing and physical activity, there are limited studies specifically focused on the relationship between flatfoot and lower limb fatigue. This is significant because functional limitations can be prevented by early detection and promotion of student well-being to avoid musculoskeletal problems. Hence, the aim of this study is to explore the relationship between the flatfoot and lower limb fatigue of university students and the potential effect of foot posture on lower limb fatigue during normal activities.

MATERIALS AND METHODS

This study was a cross-sectional observational study conducted at The University of Lahore. The study was completed over a period of six months after approval of the synopsis. About 126 participants were included in the study (based on prevalence from parent study). A non-probability convenient sampling technique was used.

A total of 126 university students aged 18–25 years were recruited for the study. Both male and female gender were eligible to participate. Participants were required to be willing to take part and give consent. They had to be independent in performing daily activities and have no immediate illness or injury that could impact mobility at this time. Participants with a past surgery or trauma to the lower leg were excluded from the study. Individuals using foot orthoses or assistive devices were also excluded. Those with any unsteadiness or balance problems and vestibular deficits were not included. Participants who had a systemic disease that causes fatigue (such as anemia and chronic disease) were also excluded.

The Foot Posture Index-6 (FPI-6) (Redmond et al., 2006) is a validated clinical assessment tool to measure foot posture based on six foot anthropological criteria in standing posture. It gives a composite score of how supinated or pronated the foot posture is and is frequently employed to diagnose flatfoot (pes planus) and its severity. The scoring and classification were as follows: Mild Flatfoot (0–5), Moderate Flatfoot (6–9), and Severe Flatfoot (10–12). The Fatigue Severity Scale (FSS) (Krupp et al., 1989) is a self-administered instrument that helps quantify fatigue and its effect on functioning. It is composed of nine statements that are rated on a 7-point Likert scale with higher scores indicative of higher levels of fatigue severity. The scoring and classification were as follows: Mild Fatigue = FSS score (9–27), Moderate Fatigue = FSS score (28–45), and Severe Fatigue = FSS score (46–63). (8) (9)

The Institutional Research Ethics Board (IREB) of The University of Lahore granted ethical approval. The study was carried out based on the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants. The confidentiality and anonymity of the participants were kept in all aspects during the study. The participants were invited to take part in the study at their own option and could withdraw at any time without any repercussion. No harm or risk was involved in the study.

After obtaining informed consent, data were collected under standardized conditions. The Foot Posture Index-6 (FPI-6) was used to assess the foot posture and the Fatigue Severity Scale (FSS) was used to assess the severity of fatigue. The data were collected systematically and were recorded for statistical analysis. University students were used to investigate the association between flatfoot and fatigue severity using Pearson's Chi-Square test.

The data were analyzed using SPSS version 27. Demographic data was summarized using descriptive statistics. Means and standard deviations were used for continuous variables, and frequencies and percentages for categorical variables. To evaluate the association between flatfoot severity (FPI-6) and fatigue severity (FSS), Pearson's Chi-Square test was used. The significance was set at p-values of ≤ 0.05.

RESULTS

The demographic characteristics of the participants are presented in Table 1. A total of 126 university students was involved in the study.

Table 1: Descriptive Statistics for Age and BMI (n = 126)

Descriptive Statistics					
	N	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Age	*126*	*18*	*25*	*21.54*	*2.372*
BMI	*126*	*17.0*	*34.0*	*22.843*	*3.5426*
Valid N (listwise)	*126*				

The mean age of the participants was 21.54 ± 2.37 years (range 18–25 years) which shows that the age group of the study population was mainly young adults. The mean Body Mass Index (BMI) of the participants was 22.84 ± 3.54 kg/m² ranging from 17.0 to 34.0 kg/m², Of the total participants, 66 (52.4%) were male and 60 (47.6%) were female.

Table 2: Association between Flatfoot Severity and Fatigue Level (Crosstabulation)

Flatfoot_Severity * Fatigue_Level Crosstabulation

	Fatigue_Level	*Total*				
	Mild	*Moderate*	*Severe*			
Flatfoot_Severity	*Mild*	*Count*	*26*	*10*	*0*	*36*
		Expected Count	*10.6*	*16.0*	*9.4*	*36.0*
		% within Flatfoot_Severity	*72.2%*	*27.8%*	*0.0%*	*100.0%*
	Moderate	*Count*	*11*	*30*	*7*	*48*
		Expected Count	*14.1*	*21.3*	*12.6*	*48.0*
		% within Flatfoot_Severity	*22.9%*	*62.5%*	*14.6%*	*100.0%*
	Severe	*Count*	*0*	*16*	*26*	*42*
		Expected Count	*12.3*	*18.7*	*11.0*	*42.0*

		% within Flatfoot_Severity	*0.0%*	*38.1%*	*61.9%*	*100.0%*
Total	*Count*	*37*	*56*	*33*	*126*	
	Expected Count	*37.0*	*56.0*	*33.0*	*126.0*	
	% within Flatfoot_Severity	*29.4%*	*44.4%*	*26.2%*	*100.0%*	

Regarding flatfoot severity, 36 (28.6%) participants had mild flatfoot, 48 (38.1%) had moderate flatfoot, and 42 (33.3%) had severe flatfoot. Regarding fatigue severity, 37 participants 29.4% participants had mild fatigue, 56 participants, 44.4% had moderate fatigue, and 33 participants 26.2% had severe fatigue.

Table 3. Association between Flatfoot Severity and Fatigue Level (Chi-Square Test)

Chi-Square Tests			
	Value	*df*	*Asymptotic Significance (2-sided)*
Pearson Chi-Square	*74.034[a]*	*4*	*<.001*
Likelihood Ratio	*83.998*	*4*	*<.001*
N of Valid Cases	*126*		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.43.

Pearson's Chi-Square test was used to determine the association between flatfoot severity and fatigue severity. The results demonstrated a statistically significant association between flatfoot severity and fatigue severity ($\chi^2 = 74.034$, df = 4, $p < 0.001$).

DISCUSSION

Demographic Characteristics of Participants

The study was carried out in the age group of 18–25 years with a mean age of 21.54 ± 2.37 years among students of University. All participants had a young and active population, where MS factors could play a role in functional performance. The average BMI was within the normal range and indicated that the relationship between the severity of flatfoot and fatigue was not likely to be affected by excess body weight. Moreover, there was a fairly equal distribution between males and females for participants, minimizing the potential for gender bias in the results. AK Buldt et al. (2013) reported the same demographic trends in young adults where functional differences still correlated with foot posture variations. (10)

Flatfoot Severity in University Students

The results showed that flatfoot was a common condition among the subjects of the study and moderate and severe flatfoot were common. Changes in the medial longitudinal arch can impact lower-limb biomechanics, distribution and gait efficiency during ambulatory activities, such as walking and standing, and alter functional performance.

The results concur with Cen et al. (2024), which revealed that the flexibility of medial longitudinal arch had significant effect on the lower-limb joint coordination and gait mechanics. They found that foot arch structure influences hip, knee and ankle motion during walking, which further supports the role of foot posture in lower-limb function. Moreover, R Periyasamy et al. (2013) found that foot posture changes affect the distribution of plantar pressures and play a role in gait mechanics. (11) (12)

Lower Limb Fatigue in University Students

Many indicated moderate to severe fatigue related to activities during the day. The causes of fatigue in university students are multi-factors and can include workload, lifestyle factors and a decrease in physical activity. The present results, however, indicate that biomechanical characteristics, such as foot posture, may be involved in fatigability as well.

Fatigue does not only occur centrally and can be influenced by peripheral muscular demands Enoka and Duchateau (2016), suggesting that changes in the mechanics of the lower-limb might have an effect on fatigue perception in daily activities. (13)

Association between Flatfoot and Lower Limb Fatigue

The present study showed a statistically significant correlation between the severity of flat foot and lower-limb fatigue ($\chi^2 = 74.034$, df = 4, $p < 0.001$). Fatigue was the outcome variable that differed between participants with higher severity of flatfoot and those with lower severity of flatfoot, suggesting that alterations in foot posture could have a negative effect on functional performance.

Results are in line with W Kawakami .el at (2024), who found a correlation between changing foot posture and greater energy cost while walking and a decrease in gait efficiency. This confirms the hypothesis that higher fatigue in lower limbs is associated with higher severity of flat foot. (14)

Biomechanical Explanation of the Findings

There is a biomechanical explanation for the association observed. The medial longitudinal arch provides an important role for shock absorption, stability and force transmission. Flatfoot causes the arch to collapse, making more demands on the muscles when they are used in functional activities.

DA Neuman (2010) reported that excessive pronation causes tibial rotation, which overloads the knee joint even more and increases the amount of the work performed by the muscles. (15)

Functional Consequences of Flatfoot

The impact of flatfoot is not just on the alignment of the feet, it also has an impact on gait mechanics, balance, movement efficiency, and muscular endurance. With time, this compensatory movement pattern can involve more muscle use in the lower limbs which can lead to fatigue in everyday activities.

Using surface electromyography analysis, Pan et al. (2026) investigated the muscle activation pattern and coordination in unilateral flat foot patients while walking. The results indicated that the muscle activity was higher and asymmetrical in the foot stability muscles, especially the arch supporting muscles, in comparison with the unaffected foot. This suggests that persons with flat foot need more muscular effort to control their posture and to keep their stability during performing functional activities like walking. The study also revealed that this greater neuromuscular demand is indicative of compensation mechanisms to support the fallen medial longitudinal arch. This led to a positive correlation between the amount of muscle recruited and the energy demand needed in locomotion. As a whole, the authors reported that the balance of muscle activities during the flatfoot position differs from normal foot position, causing greater muscle work in the lower limb and the greater muscle fatigue when performing daily activities. (16)

Clinical Implications

This study adds to the discussion of the role of early diagnosis of flatfoot in a young adult to reduce functional impairments, such as fatigue. Physiotherapy techniques such as strengthening of the intrinsic foot muscles, balance exercises, gait re-education and orthotic support can help to improve foot mechanics and lessen fatigue. There is some evidence that a strengthening programme specifically designed to strengthen the foot improves functional outcomes and arch support in flatfoot.

Comparison with Previous Research and Study Limitations in Context

The results show that the lower limb biomechanics, muscle activity and functional performance are altered by flatfoot as confirmed by previous studies. This important association confirms the current literature that foot posture is important to the function of the lower limb.

But, the cross-sectional design does not allow for causal interpretation, and self-reporting of fatigue can be subject to bias. Additionally, generalizability may be restricted since convenience sampling (from one university) was used. The relationship between flatfoot and fatigue should be investigated further with larger and more diverse populations, objective measures like gait analysis and electromyography.

CONCLUSION

The objective of this study is to find the association between flatfoot and the level of lower limb fatigue experienced during daily activities among university students. The results indicated that all the subjects had some foot posture alteration, from mild to severe, and that the prevalence of flatfoot was high. Fatigue in the lower limbs was also reported frequently for all severity levels. There was a statistically significant association between severity of flat foot and fatigue in the lower limb ($\chi^2 = 74.034$, $p = 0.001$), where higher severity of flat foot was related to higher fatigue in lower limb. The study findings suggest the presence of a relationship between flatfoot and increased lower-limb fatigue and that early recognition and treatment are important to increase functional outcomes in youth.

REFERENCES

1. Zangi M, Taheri M, Ahmadi O, Khalili Dehkordi F, Maleki A, Khosravi M. Biomechanical effects of foot orthoses in children with flexible flat foot: a systematic review. J Rehabil Assist Technol Eng. 2026;13:20556683261429364.

2. Sorrentino R, Carlson KJ, Orr CM, Pietrobelli A, Figus C, Li S, et al. Morphological and evolutionary insights into the keystone element of the human foot's medial longitudinal arch. Commun Biol. 2023;6(1):1061.

3. Hara S, Kitano M, Kudo S. The effects of short foot exercises to treat flat foot deformity: a systematic review. J Back Musculoskelet Rehabil. 2023;36(1):21-33.

4. Ataabadi PA, Abbassi A, Letafatkar A, Vanwanseele B. The effects of foot orthosis and low-dye tape on lower limb joint angles and moments during running in individuals with pes planus. Gait Posture. 2022;96:154-9.

5. Zhang L, Yan Y, Liu G, Han B, Fei J, Zhang Y. Effect of fatigue on kinematics, kinetics and muscle activities of lower limbs during gait. Proc Inst Mech Eng H. 2022;236(9):1365-74.

6. Gebel A, Busch A, Stelzel C, Hortobágyi T, Granacher U. Effects of physical and mental fatigue on postural sway and cortical activity in healthy young adults. Front Hum Neurosci. 2022;16:871930.

7. Lukman NH, Dar SM. Prevalence of flexible flat feet and its association with body mass index among young adults of Malaysian university: a preliminary cross-sectional study. Int J Allied Health Sci. 2025;9(2).

8. Redmond AC, Crosbie J, Ouvrier RA. Development and validation of a novel rating system for scoring standing foot posture: the Foot Posture Index. Clin Biomech. 2006;21(1):89-98.

9. Krupp LB, LaRocca NG, Muir-Nash J, Steinberg AD. The Fatigue Severity Scale: application to patients with multiple sclerosis and systemic lupus erythematosus. Arch Neurol. 1989;46(10):1121-3.

10. Buldt AK, Murley GS, Butterworth P, Levinger P, Menz HB, Landorf KB. The relationship between foot posture and lower limb kinematics during walking: a systematic review. Gait Posture. 2013;38(3):363-72.

11. Cen X, Yu P, Song Y, Sun D, Liang M, Bíró I, et al. Influence of medial longitudinal arch flexibility on lower limb joint coupling coordination and gait impulse. Gait Posture. 2024;114:208-14.

12. Periyasamy R, Anand S. The effect of foot arch on plantar pressure distribution during standing. J Med Eng Technol. 2013;37(5):342-7.

13. Enoka RM, Duchateau J. Translating fatigue to human performance. Med Sci Sports Exerc. 2016;48(11):2228.

14. Kawakami W, Iwamoto Y, Sekiya J, Ota M, Ishii Y, Takahashi M. Impact of pronated foot on energetic behavior and efficiency during walking. Gait Posture. 2024;107:23-7.

15. Neumann DA, Kelly ER. Kinesiology of the musculoskeletal system: foundations for rehabilitation. 2nd ed. St Louis: Mosby Elsevier; 2010.

16. Pan J, Gao Z, Zhou Z, Wang D, Li F, Chen D, et al. Muscle synergy asymmetry between the affected and unaffected limbs during the stance phase in unilateral flatfoot. J Neuroeng Rehabil. 2026.