Original article

Correlation of body mass index with foot posture and musculoskeletal disorders in the young adult population

Correlação do índice de massa corporal com a postura do pé e distúrbios musculoesqueléticos na população jovem adulta

Pallakkat Sneha Balakrishnan[1]
Amal Nelson Paulraj[2]

[1]Corresponding contact. St John's Physiotherapy College (Bangalore). Karnataka, India. 21papt107@gcu.ac.in
[2]Alva's College of Physiotherapy and Research Centre (Moodabidri). Karnataka, India.

ABSTRACT | BACKGROUND AND OBJECTIVES: The foot's posture is dependent on three bony arches: the medial longitudinal, lateral longitudinal, and transverse arches. It fluctuates with the advancement of a person's age. Irregular foot arches may lead to abnormalities and elevate the likelihood of injury. Anthropometric factors, including height, weight, and BMI, correspond with age. The study sought to establish a correlation between body mass index, foot position, and musculoskeletal disorders, including discomfort in the trunk and lower limbs. **METHODS:** A total of 55 participants aged 18 to 25 years were enrolled in the study, meeting the inclusion criteria. Foot posture was evaluated with the FPI-6 grading system in a comfortable standing position. The presence and absence of musculoskeletal pain are assessed using a custom-designed questionnaire. Additional factors such as weight (kg), height (cm), and body mass index were also assessed. **RESULTS:** The study indicated no statistically significant link between body mass index and foot posture (r = -0.047, p = 0.731). A slight positive connection is present between body mass index and musculoskeletal discomfort (r = 0.050, p = 0.715). **CONCLUSION:** The study findings indicate that varying BMI does not influence foot posture but has a marginal effect on musculoskeletal discomfort. Body mass index is not correlated with foot posture but has a modest link with the prevalence of musculoskeletal pain.

KEYWORDS: Foot Posture. Body Mass Index. Young Adult. Musculoskeletal Pain. FPI-6.

RESUMO | CONTEXTO E OBJETIVOS: A postura do pé depende de três arcos ósseos: o arco longitudinal medial, o arco longitudinal lateral e o arco transverso. Flutua com o avanço da idade de uma pessoa. Arcos do pé irregulares podem levar a anomalias e aumentar a probabilidade de lesões. Fatores antropométricos, incluindo altura, peso e IMC, correspondem com a idade. O estudo buscou estabelecer uma correlação entre o índice de massa corporal, a posição dos pés e os distúrbios musculoesqueléticos, incluindo desconforto no tronco e nos membros inferiores. **MÉTODOS:** Um total de 55 participantes, com idades entre 18 e 25 anos, foram inscritos no estudo, atendendo aos critérios de inclusão. A postura do pé foi avaliada com o sistema de classificação FPI-6 em uma posição de pé confortável. A presença e a ausência de dor musculoesquelética são avaliadas usando um questionário personalizado. Fatores adicionais, como peso (kg), altura (cm) e índice de massa corporal, também foram avaliados. **RESULTADOS:** O estudo indicou que não há ligação estatisticamente significativa entre o índice de massa corporal e a postura do pé (r = -0,047, p = 0,731). Uma leve conexão positiva está presente entre o índice de massa corporal e o desconforto musculoesquelético (r = 0,050, p = 0,715). **CONCLUSÃO:** Os resultados do estudo indicam que a variação do IMC não influencia a postura do pé, mas tem um efeito marginal no desconforto musculoesquelético. O índice de massa corporal não está correlacionado com a postura do pé, mas tem uma ligação modesta com a prevalência de dor musculoesquelética.

PALAVRAS-CHAVE: Postura do Pé. Índice de Massa Corporal. Jovem Adulto. Dor Musculoesquelética. FPI-6.

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1. Introduction

Foot posture plays a vital role as the distal support structure that directly influences postural stability. It provides a stable base for both static and dynamic activities, supported by three bony arches: the medial longitudinal, lateral longitudinal, and transverse arches[1]. Foot structure changes with age and maintaining proper alignment is essential for healthy biomechanics throughout life. Abnormal foot posture may arise from congenital conditions, improper usage, or environmental factors such as prolonged walking or standing on hard surfaces[1].

Hyper-pronation, for example, can increase mechanical demand on the ankle, knee, hip, and spine, contributing to musculoskeletal problems[2]. Body mass index (BMI) is an important factor in this context. Standard BMI classifications include underweight (≤18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), and obesity (≥30 kg/m²). Both low (<20) and high (>25) BMI values are associated with increased all-cause mortality, with the risk being more pronounced in obesity. Higher BMI has also been linked to a greater incidence of altered foot posture and related musculoskeletal issues[2].

The evolution of foot posture is closely connected to the dissipation of ground reaction forces, and factors such as body weight, height, and activity level can influence deviations in the foot posture index. Excessive body weight places higher loads on the lower extremities, increasing the likelihood of morphological changes and functional impairments[3]. Research indicates that overweight and obese children often present with flat feet due to altered foot anatomy caused by weight-bearing stress. If these conditions persist into adulthood, they may contribute to gait abnormalities and pain[4].

Several studies have examined pediatric foot morphology, but evidence among young adults remains limited. Given that weight and BMI vary with age, it is important to determine whether risk patterns observed in children and adolescents extend to adult populations[5,6]. The Foot Posture Index (FPI-6) provides a reliable, quick, and clinically applicable method for evaluating pronation, supination, or neutral alignment compared to traditional static goniometric measures. Different foot types demonstrate distinct plantar pressure patterns: planus feet show increased medial forefoot loading, while cavus feet display greater lateral forefoot and heel pressures[7].

Prevalence studies report flexible pes planus as more common in adolescents, particularly in males, and influenced by BMI and height[8]. Abnormal foot posture has also been implicated in low back pain, where corrective interventions such as orthoses may help reduce symptoms[9]. While age-related increases in the foot posture index have been documented, associations with BMI and gender remain less clear[10].

Therefore, this study aims to investigate the relationship between BMI, foot posture, and musculoskeletal problems in a young adult population. Specifically, it seeks to determine whether BMI is linked to foot posture deviations and to assess the association between BMI and musculoskeletal pain (MSK pain).

2. Materials and methods

Study design: cross-sectional study.

Demographic: young adult demographic.

Study duration: six months.

Sampling method: convenience sampling

The sample size was determined using G* Power version 3.1.94, referencing the prior study "Correlation of Body Mass Index with Foot Posture and Core Stability in the Young Adult Population" by Dhasal and Barodawala[1], resulting in a minimum requirement of 55 participants at a 95% confidence level and 90% power.

Study setting: Alva's College of Physiotherapy, Moodabidri, India.

2.1 Criteria for inclusion

- Age: 18 to 25 years old;
- All genders: male and female;
- Body mass index (BMI): underweight (<18.5), normal (18.5-25), overweight (25-30).

2.2 Exclusion criteria

- Individuals with congenital foot malformations;
- Individuals with a BMI ≥ 30;
- Individuals with systemic illnesses or musculoskeletal disorders, particularly those affecting the lower limbs, such as foot injuries, degenerative changes of the hip, knee, ankle and foot;
- Individuals with a history of recent lower-limb surgery.

2.3 Materials utilized

- Pen & pencil;
- FPI-6 datasheet;
- Custom-designed questionnaire;
- Weighing apparatus;
- Measurement tape;
- Indelible ink pen.

2.4 Procedure

Institutional ethics permission was obtained before conducting this investigation. Participants who consented and met the inclusion and exclusion criteria were selected. The subject's informed consent was obtained in advance.

The employed outcome measures were:

1) Body mass index (BMI)

To determine body mass index, the subject's height and weight were measured using a measuring tape and a weighing scale, respectively; the body mass index was thereafter computed using the formula:

$$BMI = Weight\ (kg) / Height\ (m)^2$$

2) Foot Posture Index (FPI-6)

Foot posture was assessed using the Foot Posture Index (FPI-6), a validated six-item clinical tool with high inter-rater reliability (Kw = 0.86) and internal consistency (PSI = 0.88)[3,6]. Participants stood in a relaxed, bipedal stance with arms at their sides and gazed forward.

The six clinical criteria utilised in the FPI-6 are[3,6]:

i. Palpation of the talar head;
ii. Curvature of the supra and infra lateral malleolus;
iii. Calcaneal frontal orientation;
iv. Prominence at the talonavicular joint;
v. Congruence of the medial longitudinal arch;
vi. Abduction and adduction of the forefoot relative to the rearfoot.

(Figures 1-6)

Scores were summed to yield a total between –12 (highly supinated) and +12 (highly pronated), with –1 to +1 indicating neutral. In this study, most participants scored around +3, suggesting normal to mildly pronated posture, with no notable difference between BMI categories (Figure 8).

Figure 1. Talar head palpation malleolar curvature

Source: the authors (2023).

Figure 2. Supra and infra lateral

Source: the authors (2023).

Figure 4. Talonavicular congruence

Source: the authors (2023).

Figure 3. Calcaneal inversion/eversion

Source: the authors (2023).

Figure 5. Medial arch height

Source: the authors (2023).

Figure 6. Forefoot abduction/adduction

Source: the authors (2023).

2.5 Statistical analysis

Frequencies and percentages were computed for BMI, foot posture, and musculoskeletal diseases. Analysis was conducted using descriptive statistics. The mean and standard deviation were computed for body mass index and foot posture. Comparisons between the groups were conducted using the Student's unpaired t-test or the Mann-Whitney U test, depending on the data's normality. Chi-square tests were employed for qualitative data. Correlation was assessed using Pearson's correlation coefficient. The study was conducted using the statistical software SPSS version 24.0. A p-value of less than 0.05 will be deemed significant.

3. Results

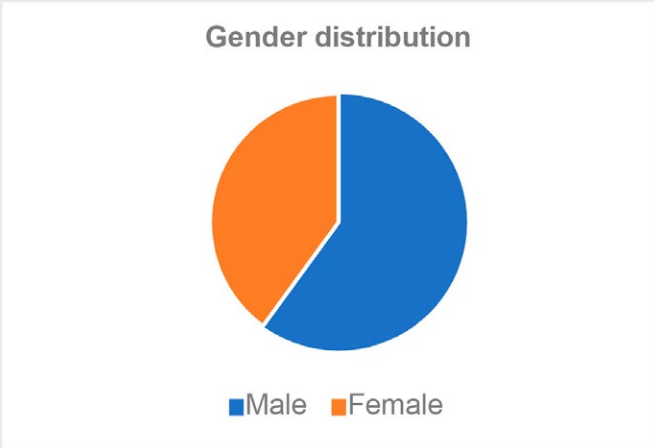
A total of 55 participants met the inclusion criteria, comprising 33 males (60%) and 22 females (40%) (Table 1, Figure 7). Participants ranged in age from 18 to 25 years, with a mean age of 20.89 ± 1.77 years. The largest age groups were 18–19 years (32.72%) and 22–23 years (32.72%).

Table 1. Gender distribution

Gender	Frequency	Percentage
Male	33	60.0
Female	22	40.0
Total	**55**	**100.0**

Source: the authors (2023).

Figure 7. Graphical representation of gender distribution



Source: the authors (2023).

Anthropometric measurements were taken using a calibrated measuring tape and weighing scale. Height was recorded in centimetres with the participant standing barefoot, and weight was measured in kilograms with minimal clothing. Body mass index (BMI) was calculated using the standard formula:

$$BMI = Weight\ (kg) / Height\ (m)^2$$

Participants were then categorized according to World Health Organization (WHO) standards: underweight (<18.5 kg/m^2), normal (18.5–24.9 kg/m^2), and overweight (25–29.9 kg/m^2). The mean BMI was 21.62 ± 3.90 kg/m^2. Among the sample, 25.45% were underweight (≤18.5 kg/m^2), 54.54% were normal weight (18.6–24.9 kg/m^2), and 20.00% were overweight (25–29.9 kg/m^2). Mean height was 164.42 ± 7.22 cm, with most participants (41.81%) in the 161–170 cm range. Mean weight was 58.36 ± 10.64 kg, and nearly half (47.27%) weighed between 40–55 kg (Table 2).

Table 2. Mean and SD of age, height, weight and BMI of participants

Variables	Range	Frequency	Mean± SD
Age (years)	18 – 19	18 (32.72)	20.89 ± 1.77
	20 – 21	15 (27.27)	
	22 – 23	18 (32.72)	
	24 - 25	4 (7.27)	
Height (cm)	151 – 160	20 (36.36)	164.42 ± 7.22
	161 – 170	23 (41.81)	
	171 - 180	12 (21.81)	
Weight (Kg)	40 – 55	26 (47.27)	58.36 ± 10.64
	56 – 70	21 (38.18)	
	71 - 85	8 (14.54)	
BMI (kg/m^2)	<18.5	14 (25.45)	21.62 ± 3.90
	18.6 – 24.9	30 (54.54)	
	25 – 29.9	11 (20)	

Source: the authors (2023).

Comparison between males and females using the Mann–Whitney U test (Table 3) revealed that females had significantly higher mean rank for age (p = 0.001), while males had significantly greater mean rank for height (p = 0.001) and weight (p = 0.024). There were no significant differences in BMI, FPI-6 scores, or MSK pain prevalence between genders (p > 0.05).

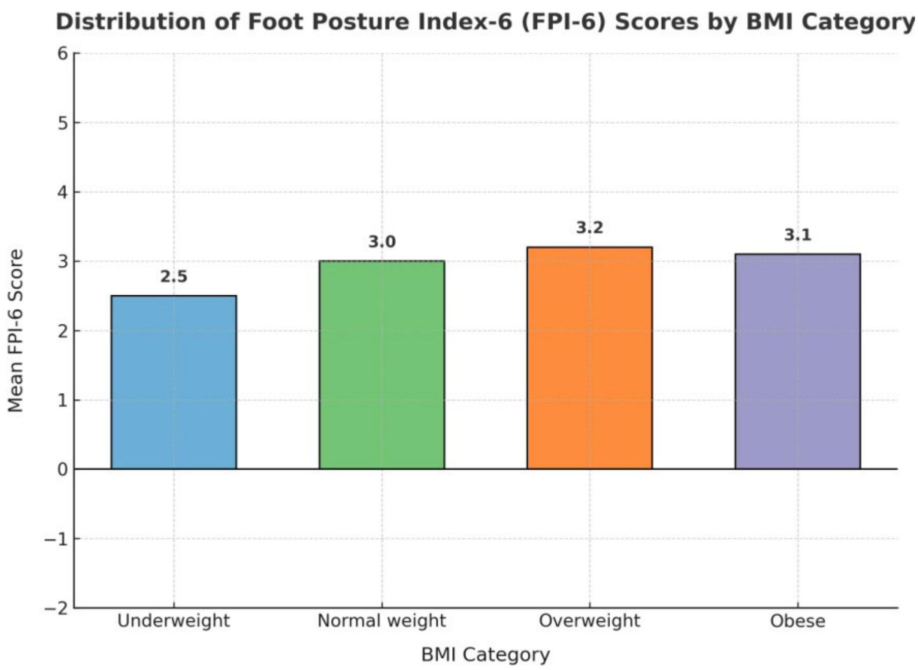
Table 3. Comparison of male and females with other variables by Mann-Whitney U test

Variables	Male (mean rank)	Female (mean rank)	*Z* value	*P* value
Age	21.92	37.11	-3.511	0.001*
Height	36.52	15.23	-4.840	0.001*
Weight	31.97	22.05	-2.253	0.024*
BMI	28.11	27.84	-0.060	0.952
FPI 6	26.23	30.66	-1.017	0.309
MSK pain	26.83	29.75	-1.470	0.141

Source: the authors (2023).
*Significant at $p < 0.05$.

FPI-6 scores ranged from negative to positive values, where negative scores indicated supination and positive scores indicated pronation. Most participants, regardless of BMI category, scored around +3, indicating normal foot posture (Figure 8).

Figure 8. Distribution of Foot Posture Index-6 (FPI-6) scores among participants by BMI category



Source: the authors (2023).

Pearson's correlation analysis (Table 4) found no significant relationship between BMI and FPI-6 score (r = –0.047, p = 0.731) or between BMI and MSK pain (r = 0.050, p = 0.715). Scatter plots (Figures 9 and 10) illustrate the lack of clear trends in these relationships. Overall, BMI did not significantly correlate with either foot posture or musculoskeletal pain in this young adult sample. While females reported pain more often than males, the difference was not statistically significant.

Table 4. Correlation coefficient of BMI with FPI and MSK pain

	R value	*P* value	*T* value
BMI – FPI	-0.047	0.731	-0.346
BMI – MSK pain	0.050	0.715	0.368

Source: the authors (2023).

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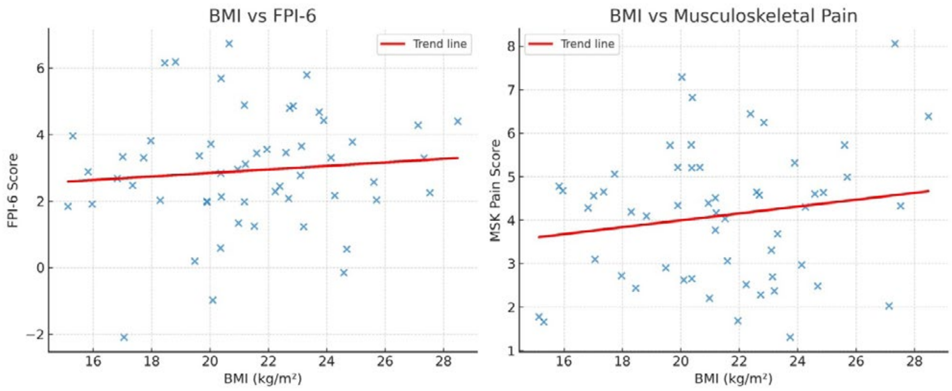
Figure 9. Scatter plots showing correlation between BMI and FPI-6 scores, BMI and musculoskeletal pain



Source: the authors (2023).

The scatter plot shows the correlation between BMI and FPI-6 scores with a fitted trend line (weak negative relationship, $r \approx -0.05$). The plot illustrates the correlation between BMI and musculoskeletal pain prevalence with a fitted trend line (very weak positive relationship, $r \approx +0.05$). Musculoskeletal pain, when present, was most frequently reported in the knee and lower back regions.

4. Discussion

The present study explored the relationship between body mass index (BMI), foot posture, and musculoskeletal discomfort in young adults aged 18–25 years. A total of 55 participants, including both males and females, took part. Results revealed a negative association between BMI and foot posture, alongside a weak positive correlation between BMI and musculoskeletal discomfort. Lower back and knee pain emerged as the most common complaints, while upper back, hip, and ankle discomfort were not reported.

Previous research highlights that foot posture significantly influences lower limb mechanical alignment and dynamic function, potentially contributing to musculoskeletal disorders. Assessing the Foot Posture Index (FPI-6) allows detection of persistent deviations and facilitates early intervention to prevent deformities and dysfunctions. The current findings suggest that BMI exerts minimal influence on foot posture but may be weakly linked to musculoskeletal discomfort.

Studies in comparable populations report mixed findings. Dhasal and Barodawala found a positive correlation between BMI, foot posture, and core stability in young adults[1], while Arthi reported no significant effect of BMI on foot posture type[5]. Buldt et al. linked foot posture to unique plantar pressure profiles[7], and Tenenbaum et al. associated flexible pes planus with increased BMI[8]. Other works suggests BMI may influence pronation tendency, knee pain, and disability, though results vary by age, sex, and population[9-12]. Additional studies have reported associations between elevated BMI and greater musculoskeletal symptoms, particularly in weight-bearing joints, and slower recovery from such symptoms.

In this study, the mean BMI (21.62 kg/m²) fell below the overweight threshold, which may explain the relatively low prevalence of foot posture deviations and musculoskeletal discomfort. Over half of the participants (54.54%) had a normal BMI, 25.45% were underweight, and 20.00% were overweight. Physical fitness levels, activity participation, and the predominance of male participants (n = 33, 60.00%) may also have influenced the low incidence of reported discomfort.

Research has consistently demonstrated that body mass index (BMI) plays a significant role in musculoskeletal health, particularly in the lower limbs. Higher BMI has been linked to altered foot and ankle characteristics and increased knee symptoms, as observed in individuals with patellofemoral osteoarthritis[13]. Evidence also shows that elevated BMI is associated with a greater prevalence of musculoskeletal pain, affecting mobility and overall function across different populations[14]. Longitudinal data further indicate that obesity in early adulthood predicts knee pain and walking difficulties later in life, reinforcing its long-term biomechanical consequences[15]. Studies among working adults similarly report a positive association between higher BMI and musculoskeletal symptoms, suggesting that excess body weight increases mechanical stress on lower-extremity joints during daily activities[16]. Moreover, BMI has been shown to influence foot posture alignment and core stability, with overweight individuals demonstrating increased foot pronation and reduced neuromuscular control[17]. Recent findings among university students and young adults also confirm that BMI interacts with static foot posture and core stability, with higher BMI groups presenting more abnormal foot posture types and compromised trunk control[18,19]. Collectively, these findings underscore the importance of considering BMI in the assessment of lower-limb biomechanics and musculoskeletal function.

4.1 Limitations

The study's limitations include an uneven distribution across BMI categories, an imbalanced male-to-female ratio, and a small, student-only sample. The use of convenience sampling may also have introduced bias, limiting generalizability.

5. Conclusions

The current study concludes that varying body mass indices, such as underweight, normal, and overweight, do not influence foot posture in both males and females. The majority of subjects had a normal to slightly pronated foot posture, regardless of their body mass index. There is a slight positive connection between body mass index and the occurrence of musculoskeletal discomfort. The prevalent locations of musculoskeletal pain were the lower back and knee joint.

Authors' contributions

The authors declared that they have made substantial contributions to the work in terms of the conception or design of the research; the acquisition, analysis or interpretation of data for the work; and the writing or critical review for relevant intellectual content. All authors approved the final version to be published and agreed to take public responsibility for all aspects of the study.

Competing interests

No financial, legal, or political conflicts involving third parties (government, private companies, and foundations, etc.) were declared for any aspect of the submitted work (including but not limited to grants and funding, advisory board participation, study design, manuscript preparation, statistical analysis, etc.).

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