

Association of Body Mass Index with Foot Posture Types and Core Muscle Endurance Among Young Adults: An Observational Study

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DOI: <https://doi.org/10.52403/ijhsr.20251003>

ABSTRACT

Background: Body Mass Index (BMI), foot posture, and core muscles endurance are critical factors in the assessment of functional capacity and prevention of musculoskeletal dysfunction.

Objective: To evaluate an association between BMI and foot posture and core muscle endurance among young adults.

Methods: Through convenient sampling, data was obtained for an observational cross-sectional study of 212 young adults (106 males, 106 female) aged 18-25. BMI was calculated using WHO (World Health Organization) protocols. Foot posture was measured using Foot Posture Index (FPI-6), which categorized the feet as being pronated, normal, or supinated. Core muscle endurance was administered by prone plank test. All data were analyzed using SPSS v20, using Pearson correlation coefficient.

Results: For females, the BMI values had a significant moderate positive correlation with left foot posture ($r = 0.576$, $p = <0.001$) and right foot posture ($r = 0.585$, $p = <0.001$). For males, there was also significant relationships between BMI and their left foot posture ($r = 0.650$, $p = <0.001$) and right foot posture ($r = 0.666$, $p = <0.001$). The study found a significant negative correlation between BMI and core muscle endurance in males ($r = -0.264$, $p = 0.006$), and a non-significant value in females ($r = -0.126$, $p = 0.197$).

Conclusion: Increased BMI is correlated with pronated foot posture in both groups of young adults studied. In fact, females were found to be at a greater risk of flat feet with an increased BMI. Furthermore, increased BMI was adversely associated with core muscle endurance especially in males.

Keywords: Body Mass Index, Foot Posture Index, Prone Plank Test, Core Muscle Endurance, Young Adults.

INTRODUCTION

Young adulthood (aged 18 to 25 years) is a transitional stage of development characterized by extreme and dynamic physical, psychological, and lifestyle changes that will ultimately determine a person's long-term health outcomes

including Body Mass Index (BMI) and musculoskeletal health [1,2]. Typically, during this time, young adults develop behaviors that persist a lifetime with respect to diet, physical activity, and stress management, which are all factors that

contribute to BMI and physical performance [1,3].

BMI is a useful anthropometric index in assessing populations of individuals as healthy, underweight, overweight, and obese and has been regarded to be a better overall health component in populations generally. In young adults, deviations from BMI have been shown to indicate possible earlier metabolic risk in addition to earlier musculoskeletal risks such as significant postural alignment changes, increased load on joints and loss of core stability which indicates they may have higher risks of developing non-communicable diseases later in life[2,4].

Foot posture, which can be categorized as neutral, pronated, or supinated, is typically assessed using the Foot Posture Index (FPI-6), which has implications for postural control and lower limb function. Studies have identified higher BMI as potentially positively associated with pronated foot posture due to increased mechanical loading on the medial longitudinal arch, which can result in postural compensations and ineffective gait mechanisms [5,6]. Some studies maintain a moderate relationship between BMI and pronation in healthy adults, while others have noted inconsistent strength associations moderated by sex and activity level [6,7].

Core muscle endurance, defined as the ability of trunk muscles to maintain contraction over time, is important for spinal stability, load transfer, and dynamic postural control. Higher BMI is associated with decreased core muscle endurance, especially in sedentary, or overweight/obese young adults [2,3]. Research has demonstrated that overweight would perform poorly on endurance-based tests. It is suggested that overweight individuals have a bio-mechanical and metabolic disadvantage [2,4].

While BMI, foot posture, and core muscle endurance have been studied in isolation, little research has been conducted on the combination of these three variables in young adults. A study with young college students

has found a significant relation between higher BMI, altered foot posture, and lower core muscle endurance in males, but not in females [7]. This shows the value of early screening in physiotherapy practice to facilitate the detection and treatment of biophysical deviations in those in this age group in order to assist in injury prevention.

MATERIALS AND METHODOLOGY

Study Design and Study Setting:

This research was designed as an observational cross-sectional study to investigate the relationship between body mass index (BMI), foot posture, and core muscle endurance in healthy young adults, and performed at SBB college of physiotherapy, Ahmedabad. The study protocol followed the terms of the declaration of Helsinki (2013 revision). Informed verbal consent was obtained from all the participants prior to the study.

Participants:

A total of 212 participants (106 males and 106 females), aged 18–25 years, were recruited using a convenient sampling technique.

Inclusion criteria:

- Healthy individuals aged 18–25 years
- Normal, Overweight, and Obese people
- Both Gender

Exclusion criteria:

- Previous lower limb surgery or fractures
- Congenital foot deformities or clinically diagnosed flat feet
- Presence of pain, instability, or acute injury at the time of testing
- Spinal or Musculoskeletal deformities
- Foot problems like talus or calcaneal fractures or Plantar fasciitis

Materials for Data collection:

- ✧ Weighing machine
- ✧ Stadiometer
- ✧ Stopwatch
- ✧ Exercise mat
- ✧ Foot posture index sheet

PROCEDURE

Participants (n = 212) from a population, consisting of 106 males and 106 females were chosen because they satisfied the inclusion criteria and were willing to take part in the present study. After getting a consent, Demographic data were obtained from the participants including their location of residence, their employment status, and their education level, lower limb dominant and non-dominant side and noted the information on the data collection form. The confidentiality of all participants was maintained, the participants' height and weight were measured and calculated the participants' Body Mass Index (BMI) and then completing the Foot Posture Index, according to how the subjects stood and the position being Static Foot Posture by Foot Posture Index -6 (FPI-6), Then completed the Core Stability test with a Prone Plank Test, in the Prone bridge position.

1. Anthropometric Assessment: Height (cm) was measured using a stadiometer. Weight (kg) was recorded using a calibrated digital weighing scale.

BMI was calculated using the formula:

$$BMI = \frac{Weight (kg)}{Height (m^2)}$$

Classification of BMI was performed according to World Health Organization (WHO) criteria: underweight (<18.5 kg/m²), normal (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), and obese (≥30 kg/m²) [8].

2. Foot Posture Assessment: The Foot Posture Index (FPI) evaluates and rates static foot posture on six criteria, in which the participant is standing relaxed in an upright posture. The six criteria are: (i) Talar head palpation (ii) observation of the curve above and below the lateral malleoli, (iii) frontal plane position of the calcaneus, (iv) The medial prominence of the talonavicular joint, (v) The congruence of the medial longitudinal arch, and (vi) The abduction/adduction of the forefoot on the rear foot. Each of the criteria is scored, -2 to +2, on a five-point scale, and are summed for a total score of -12 (highly supinated) to +12 (highly pronated) [9].



(Figure 1 (A, B, C = Foot posture assessment by FPI-6)

3. Core Muscle Endurance Assessment: Core muscle endurance was evaluated using the Prone Plank Test, a reliable measure of trunk stability. Participants assumed a forearm plank position, maintaining a straight alignment of the head, trunk, and

lower extremities. The endurance score was measured as the duration (in seconds) of holding the plank. The test was terminated when the participant could no longer sustain correct alignment, or Voluntary cessation occurred due to fatigue.



Figure 2. Prone Plank Test

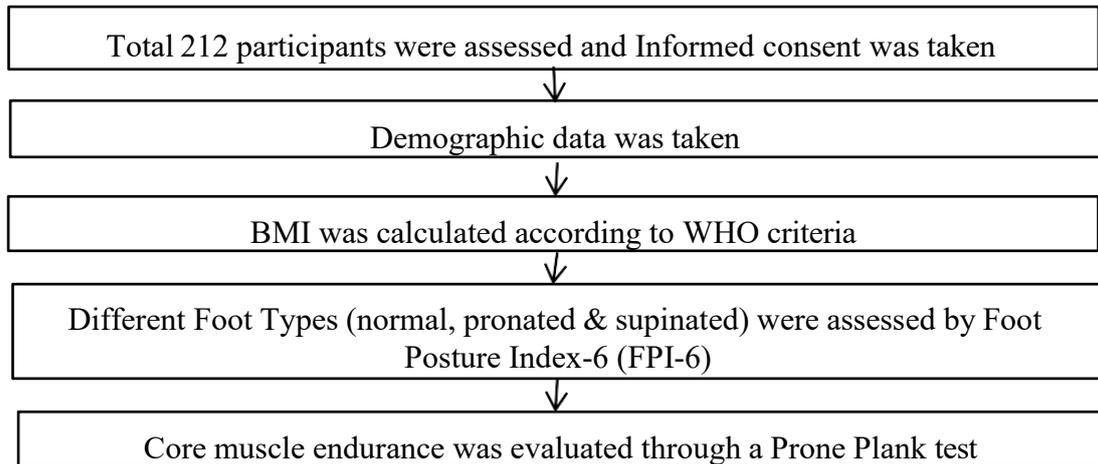


Figure 3. Method of the study

STATISTICAL ANALYSIS

Data analysis was done using Microsoft Excel and Statistical Package for the Social Sciences (SPSS) version 20. For demographic and clinical variables, descriptive statistics (mean and standard deviations) were calculated. Using the Pearson correlation coefficient, analysis was used to find out the relationship of body mass

index (BMI), foot posture, and core muscle endurance in healthy young adults. A p-value of $<.05$ was considered statistically significant.

RESULTS

Total 212 (106 Males, 106 Females) young adults were studied. Descriptive statistics as shown in Table 1.

Table 1. Demographic and Clinical Characteristic of Participants

COMPONENTS	MEAN \pm SD
Age (years)	21.98 \pm 2.03
BMI (Body Mass Index) (kg/m ²)	23.02 \pm 4.11
Prone Plank Test (sec)	42.40 \pm 25.74

Table 2. Correlation of BMI with Left & Right foot posture and Core muscle endurance (* Shows Statistical Significance)

Variable	Male (r, p)	Female (r, p)
BMI – Left Foot Posture	0.65, $<0.001^*$	0.576, $<0.001^*$
BMI – Right Foot Posture	0.66, $<0.001^*$	0.585, $<0.001^*$
BMI – Core Muscle Endurance	-0.264, 0.006*	-0.126, 0.197

The correlational analysis identified a statistically significant positive correlation between Body Mass Index (BMI) and foot posture in both males and females (Table 2). There was a positive correlation between

BMI and left foot posture in males ($r = 0.65$, $p < 0.001$) and right foot posture in males ($r = 0.66$, $p < 0.001$). Similar results were found in females as positive correlations were found in BMI with left foot posture ($r =$

0.576, $p < 0.001$) and with right foot posture ($r = 0.585$, $p < 0.001$). BMI significantly correlated negatively with core muscle endurance in males ($r = -0.264$, $p = 0.006$), while the correlation between BMI and core

muscle endurance in females was weakly negatively correlated and was not statistically significant ($r = -0.126$, $p = 0.197$).

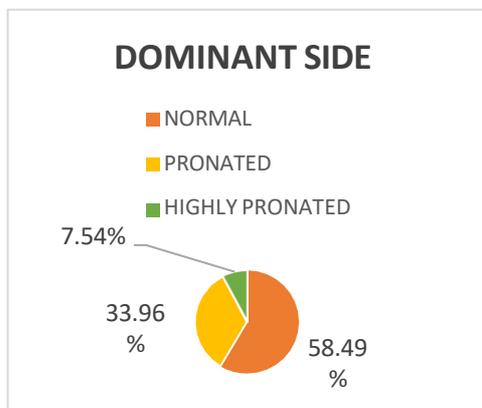


Figure 4 (A) Analysis of Dominant Side foot posture

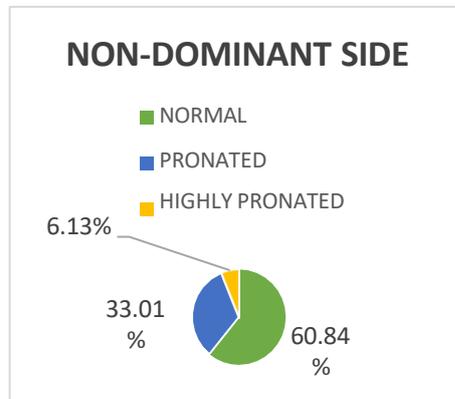


Figure 4 (B) Analysis of non-dominant Side foot posture

The dominant side foot posture was normal in 58.49% of participants, pronated in 33.96%, and highly pronated in 7.54% of participants. The non-dominant side foot posture was normal in 60.84% of participants, pronated in 33.01%, and highly pronated in 6.13% of participants. The frequency of normal posture was slightly higher on the non-dominant side than the dominant side, while pronated and highly pronated posture was slightly more frequent on the dominant side as per shown in Fig 4 (A, B).

DISCUSSION

The Current research revealed BMI was associated with foot posture in both populations in Females reported more pronation than Males suggesting a greater BMI would contribute an increased risk of flat feet accepting increased loading on the medial arch. Differences in Obesity and musculoskeletal between males and females can be responsible for variations in core endurance and foot posture between both genders. All the studies reveal that optimal foot mechanics as well as trunk stability require healthy BMI in young adults in order to avoid the risk of musculoskeletal dysfunction.

Zhang et al. (2024) documented higher prevalence of flatfoot and abnormal plantar pressure distribution in adolescents with elevated BMI, deducing that body excess weight is an etiological factor for flatfoot development that has to be treated early enough to avoid subsequent musculoskeletal complications due to higher body mass that increases plantar loading and hastens arch collapse [10]. Canca-Sánchez et al. (2024) concluded that BMI, foot posture, and some demographic factors are predictors of foot pain, noting that correction of foot posture and weight control are imperative to lowering morbidity in the feet most probably secondary to changed biomechanics and greater stress upon weight-bearing structures [11]. Likewise, Aydoğan et al. (2024) discovered that overweight university students manifested worse trunk endurance and mobility, and they concluded that functional capacity worsens as BMI increases and should be controlled with intervention methods because excess weight elevates mechanical demand and compromises neuromuscular efficiency [3]. Tank et al. (2023) concluded that higher BMI was negatively correlated with plank holding time in rural children, indicating that overweight children demonstrate lower core

endurance, as excess body mass increases mechanical demand on trunk stabilizers and leads to earlier fatigue [12]. Almutairi et al. (2022) documented a significant correlation between plank endurance and balance capacity, and they concluded that compromised postural stability could be caused by less core strength in persons with excessive body weight, as added mass impairs neuromuscular control and efficiency of balance [13].

Rosende-Bautista et al. (2021) found that greater BMI alters the structure of the medial arch and emphasized the need to consider this during clinical examination, as excess body mass increases plantar loading and lowers arch height [14]. Khan et al. (2020) reported that women are more prone to pronation, concluding that BMI and sex both influence foot posture and must be considered during assessment, since higher weight and structural differences between sexes affect alignment and loading patterns [6].

De Carvalho et al. (2017) investigated adolescents and found that BMI and gender were correlated with Foot Posture Index scores, indicating that body composition and sex differences guide foot posture, likely because excess body mass alters lower limb alignment while sex-related structural variations influence foot mechanics [15]. Similarly, AlAbdulwahab et al. (2016) established a positive correlation between BMI and pronated foot posture and a negative correlation with core stability, concluding that overweight influences biomechanics and trunk endurance, as the added load increases medial arch collapse and challenges neuromuscular control of the trunk [4]. Aurichio et al. (2011) also reported that obese women presented with flatter feet and obese men with more pronated feet, concluding that BMI affects foot type due to altered mechanical loading, since greater body weight increases plantar pressure and changes load distribution [16]. Finally, Mayer et al. (2012) reported reduced trunk endurance in obese adults and concluded that excess body mass adversely affects core

stability and may predispose individuals to back dysfunction, which can be attributed to increased mechanical demand on trunk muscles and fat infiltration reducing muscle efficiency [17].

Overall, these findings are in accord with our findings that BMI enhances risk for pronated foot posture and decreased core endurance among young adults, with females at higher risk of flatfoot and males with decreased trunk endurance. Together, these findings further emphasize the importance of weight management, foot posture screening, and core stability training as pillars of musculoskeletal health maintenance in young adults.

CONCLUSION

The study disclosed a strong association of BMI to foot posture for both males and females, although females exhibited higher levels of pronation than males, suggesting the relative risk of developing flat feet, increases because of their higher BMI. BMI negatively correlated to male core muscle endurance, suggesting increases in body mass decrease trunk stability.

Limitations

- Factors like physical activity level, diet, type of footwear, and previous history of musculoskeletal injuries were uncontrolled confounding variables.
- BMI alone was used as the measure of body composition, without assessment of body fat percentage or muscle mass.

Future Recommendations

- Future studies should utilize better methods for examining body composition beyond BMI, for example, Skinfold Caliper measurements, in combination with Waist-to-Hip Ratio (WHR), allow more precise characterization of adiposity.
- Lifestyle factors (including physical activity levels, diet, nutrition, and lifestyle factors related to footwear) should also be studied to evaluate their

contribution to foot posture and core endurance capabilities.

- There should also be long-term intervention programs that evaluate weight loss, targeted foot posture correction, and core muscle strengthening intent to design a preventative physiotherapy approach.

Abbreviations

BMI – Body Mass Index

FPI-6 – Foot Posture Index (6-point version)

SPSS – Statistical Package for the Social Sciences

WHO – World Health Organization

SD – Standard Deviation

r – Pearson's Correlation Coefficient

p – Probability Value

Declaration by Authors

Ethical Approval: Approved

Acknowledgement: We would like to thank all the subjects of this study. I would also like to give a special thank you to the staff and faculty at SBB College of Physiotherapy, Ahmedabad, for their assistance in collecting this information.

Source of Funding: No external funding was received for this study.

Conflict of Interest: The authors confirm that there are no potential conflicts of interest.

REFERENCES

1. Sun F, He Q, Sun X, Wang J. The association between body mass index and muscular fitness in Chinese college freshmen. *International Journal of Environmental Research and Public Health*. 2022 Oct 28;19(21):14060.
2. Pathak A, Shrestha Desai S, Yadav K. Association between body mass index and core muscle endurance in young adults: a cross-sectional study. *Paripex Indian J Res*. 2023;12(1):66-7.
3. AYDOĞAN K, KOSTANOĞLU A, TÖRPÜ GC. Effect of Body Mass Index on Balance, Trunk Muscle Endurance, Functional Mobility and, Physical Activity in College Students. *Bezmialem Science*. 2024 Nov 4.
4. AlAbdulwahab SS, Kachanathu SJ. Effects of body mass index on foot posture alignment and core stability in a healthy adult population. *Journal of exercise rehabilitation*. 2016 Jun 30;12(3):182.
5. Shrihari LK, Kulkarni S, Dsouza RS, Kour H. Relationship between Body Mass Index (BMI) and Foot Posture Index (FPI) among healthy adults aged 20-30 years-an observational cross-sectional study. *RGUHS Journal of Physiotherapy*. 2023;3(3).
6. Khan FR, Chevidikunna MF, Mazi AF, Aljawi SF, Mizan FH, BinMulayh EA, Sahu KS, Al-Lehidan NS. Factors affecting foot posture in young adults: A cross sectional study. *Journal of Musculoskeletal & Neuronal Interactions*. 2020;20(2):216.
7. Charmode, Sundip & Pujari, Dinanath & Shivappa, Kadlimatti & Teli, Chandrika. (2020). Correlation of Foot Dimensions with Body Mass Index: A Study in Young Population of Central India. *Indian Journal of Anatomy*. 9. 61-68. 10.21088/ija.2320.0022.9120.9.
8. World Health Organization. World Health Organization BMI Classification. World Health Organization. 2020.
9. Redmond AC, Crosbie J, Ouvrier RA. Development and validation of a novel rating system for scoring standing foot posture: the Foot Posture Index. *Clinical biomechanics*. 2006 Jan 1;21(1):89-98.
10. Shen J, Liu J, Liang F, Liu X, Zhang M. Prevalence of flatfoot and analysis of plantar pressure distribution in adolescents based on body mass index: a regional study. *Journal of Orthopaedic Surgery and Research*. 2024 Dec 23;19(1):864.
11. Canca-Sanchez FJ, Morales-Asencio JM, Ortega-Avila AB, Gijon-Nogueron G, Cervera-Garvi P, Marchena-Rodriguez A, Canca-Sanchez JC. Predictive factors for foot pain in the adult population. *BMC musculoskeletal disorders*. 2024 Jan 12;25(1):52.
12. Tank SN, Prajapati H. Correlation Between Body Mass Index and Plank Holding Time in Rural Children. *Int. J. Health Sci. Res*. 2023;13(2):149-51. DOI: <https://doi.org/10.52403/ijhsr.20230221>
13. Almutairi N, Alanazi A, Seyam M, Kashoo FZ, Alyahya D, Unnikrishnan R. Relationship between core muscle strength and dynamic balance among hospital staff. *Bull Fac Phys Ther*. 2022;27(1):24. doi:10.1186/s43161-022-00082-y.

14. Rosende-Bautista C, Munuera-Martínez PV, Seoane-Pillado T, Reina-Bueno M, Alonso-Tajes F, Pérez-García S, Domínguez-Maldonado G. Relationship of body mass index and footprint morphology to the actual height of the medial longitudinal arch of the foot. *International Journal of Environmental Research and Public Health*. 2021 Sep 17;18(18):9815.
 15. Carvalho, Barbarah & Penha, Patrícia & Penha, Náríma & Mantelatto Andrade, Rodrigo & Ribeiro, Ana & João, Sílvia. (2017). The influence of gender and body mass index on the FPI-6 evaluated foot posture of 10- to 14-year-old school children in São Paulo, Brazil: A cross-sectional study. *Journal of Foot and Ankle Research*. 10. 10.1186/s13047-016-0183-0.
 16. Aurichio TR, Rebelatto JR, De Castro AP. The relationship between the body mass index (BMI) and foot posture in elderly people. *Archives of gerontology and geriatrics*. 2011 Mar 1;52(2):e89-92.
 17. Mayer JM, Nuzzo JL, Chen R, Quillen WS, Verna JL, Miro R, Dagenais S. The impact of obesity on back and core muscular endurance in firefighters. *Journal of obesity*. 2012;2012(1):729283.
- How to cite this article: Harsh Brahmhatt, Payal Gahlot. Association of body mass index with foot posture types and core muscle endurance among young adults: an observational study. *Int J Health Sci Res*. 2025; 15(10):20-27.
DOI: <https://doi.org/10.52403/ijhsr.20251003>
