

Prevalence of Flexible Flat Feet and its Association with Body Mass Index Among Young Adults of Malaysian University: A Preliminary Cross-Sectional Study

Nur Hazimah binti Lukman, Shahid Mohd Dar*

Department of Physical Rehabilitation Sciences, Kulliyah of Allied Health Sciences, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia.

ABSTRACT

Background: Flexible flat feet (FFF) are common yet often overlooked, especially among young adults. While excess body weight has been suggested as a contributing factor but the relationship between body mass index (BMI) and FFF remains unclear due to conflicting evidence. This study aimed to determine the prevalence of flexible flat feet and examine its association with BMI among young adults. **Methods:** A cross-sectional study was conducted among 190 university students aged 19–26 years. Flexible flat feet were assessed using the Navicular Drop Test and Jack's Toe-Raising Test. BMI was calculated based on measured height and weight and categorized into four groups. The prevalence of FFF was reported in frequency and percentages, while associations with BMI were analysed using the Chi-square test of independence, with Fisher's Exact Test applied when Chi-square assumptions were not met. Cramér's V was used to assess the effect size. **Results:** Flexible flat feet were identified in 26.3% (n = 50) of participants, with 20.0% having FFF on the left side, 18.4% on the right side, and 12.1% bilaterally. No significant associations were found between BMI and FFF: right foot (Fisher's Exact Test, p = 0.222; Cramér's V = 0.152), left foot (Fisher's Exact Test, p = 0.093; Cramér's V = 0.180), and bilateral (Fisher's Exact Test, p = 0.758; Cramér's V = 0.091). Effect sizes were small in all cases. **Conclusion:** Flexible flat feet affected nearly one-fifth of the study population. No significant association was found between BMI and FFF, suggesting that BMI alone may not be a reliable indicator of foot posture in young adults. These findings support the need for broader investigations incorporating other biomechanical and lifestyle factors.

Keywords:

Body Mass Index; flat foot; young adult; cross-sectional studies

Article history:

Received: 22 January 2025

Accepted: 23 June 2025

INTRODUCTION

The human foot complex, an essential unit of lower limb has a very complex anatomical structure that assists in weight bearing by countering the rotational forces applied by proximal joints of lower limb. Its flexible structure provides a shock absorption feature which enables the plantar region to accommodate force on different surfaces during locomotion. Other than that, the foot has a substantial role in postural control and balance during standing (Viseux, 2020). Considering these essential functions, any structural or nonstructural pathology on the foot can be disabling and affect the quality of life. One such pathology is flat foot or pes planus, which is defined as the loss of medial longitudinal arch of the foot, heel valgus deformity and medial talar prominence (Troiano et al., 2017). Flat foot is classified based on various criteria and one of it is whether the flat foot structure is rigid or flexible. Flexible flat foot (FFF) is the commonest type in which the medial longitudinal arch appears to be normal in a non-weight bearing position but the arch drops excessively on standing (Neumann et al., 2017). Whereas in rigid flatfoot, the medial longitudinal arch is flattened in both weight bearing and non-weight bearing positions

(Halabchi et al., 2013). Studies have reported the prevalence of flexible flat feet to be significant among young adults. Research indicates a prevalence rate of 20% among individuals aged 18–25 years (Abaraogu et al., 2016) while another study found it to be 13.6% in adults aged 18–21 years (Aenumulapalli et al., 2017). Whereas some studies have reported the prevalence of flexible flat foot as high as 78 percent (Nakhanakhup & Ingkatecha, 2014).

Despite its high prevalence, flexible flat feet often go unnoticed due to their asymptomatic nature. However, they can impact lower limb joints in a distal-to-proximal sequence, affecting the foot, knee, hip, and lumbar spine as part of a dynamic kinetic chain (Anvita Telang & Supriya Dhumale, 2020). Studies show that foot pronation induces medial rotational torque in the tibia, leading to internal rotation in the femur, which affects pelvic alignment and spinal posture (Khamis et al., 2015; Rockar, 1995). A strong correlation was found between flat feet condition and core muscle endurance, with individuals having flexible flat feet, exhibiting reduced core muscle endurance (Elataar et al., 2020; V & Roshan, 2021). The association between flat feet and reduced core muscle endurance highlights the

* Corresponding author.

E-mail address: shahiddar@iium.edu.my

importance of identifying and managing this condition early, as untreated flatfoot can lead to further musculoskeletal issues. Hence need for increased awareness and attention to potential consequences related to flat feet should be addressed in general population.

The cause of flat feet remains a topic of ongoing debate among researchers, with various factors proposed. Some studies highlight the role of improper footwear as an important contributing factor (Bhaskara Rao & Joseph, 1992; Joseph, 1995). Some authors point to obesity or elevated body mass index (BMI) as one of the causes of flat feet among adults as well as among children, due to the excessive pressure exerted by increased body weight on the medial longitudinal arch (Senadheera, 2016; Vijayakumar et al., 2016). The strong association claimed by the studies makes this population susceptible to lumbar spine disorders in future due to the altered biomechanics caused by foot pronation and arch collapse, which can affect alignment throughout the kinetic chain, including the pelvis and spine (Anvita Telang & Supriya Dhumale, 2020; Khamis et al., 2015). Although several studies have reported a significant association between BMI and flat feet, findings remain inconsistent, with some reporting no relationship at all (Atamtürk, 2009; Carvalho et al., 2017).

To our knowledge there is currently no data on prevalence of flexible flat feet and its link to BMI within Malaysia, where racial and ethnic variations may influence both BMI distribution and foot structure, potentially affecting the relationship between the two. Given these inconsistencies in literature and the lack of data within the Malaysian context, this study serves as a preliminary cross-sectional investigation to estimate the prevalence of FFF and to investigate its relationship with BMI among Malaysian young adults.

MATERIALS AND METHODS

Study design

The study was conducted at a local university Campus, chosen for its convenient location and accessibility to participants. A cross-sectional design was used to estimate the prevalence and examine the association between flexible flat feet and body mass index (BMI) in male and female students who met the inclusion and exclusion criteria.

Participants

A non-probability convenience sampling method was used, selecting easily accessible participants. Information

was shared via a poster and viral message across WhatsApp groups, inviting voluntary participation. Informed consent was obtained from all participants.

The sample size was calculated using the single proportion formula to estimate prevalence of flexible flat feet in the study population. Based on an expected prevalence of 13.6% with a 95% confidence interval, 5% precision (Aenumulapalli et al., 2017), and accounting for a 5% non-response rate, the required sample size was approximately 190 participants.

While the sample size was primarily calculated to estimate prevalence, it was also used to explore the association between BMI and flexible flat feet. Based on Vijayakumar et al. (2016), who reported a strong relationship between BMI and flat feet in a sample of 412 adults, we conservatively estimated a large effect size (Cramér's $V = 0.30$). Using this value for power analysis ($\alpha = 0.05$, power = 0.80, $df = 3$), the minimum required sample size would be approximately 88 participants. Since our study included 190 participants, the sample size was more than adequate to detect an association of this magnitude.

Participants aged 19-26 years, enrolled at International Islamic University of Malaysia (IIUM), Kuantan Campus, with no prior history of ankle and foot injuries, without any history of back pain were included. Exclusions included individuals with foot pain, injury, surgery, neurological issues, congenital deformities, or those using orthopaedic foot devices. University students were chosen due to their accessibility and their representation of the young adult age group (18–26 years), which is commonly studied in flexible flat foot research due to its higher prevalence and relevance for early screening (Abaraogu et al., 2016; Aenumulapalli et al., 2017).

Data collection

Interested participants, who responded to recruitment messages shared via student WhatsApp groups, were invited to the assessment area, where their eligibility was screened prior to participation. Data collection was carried out over a period of three months, from October to December 2024. Those meeting the criteria received a detailed study explanation, and informed consent was obtained. Data collection consisted of three parts: demographic data, BMI measurements, and foot assessment. A single assessor conducted all examinations. This assessor was trained and supervised by a qualified physiotherapist prior to the start of data collection to ensure consistency and accuracy.

Basic demographic information of participants was recorded; weight and height were measured. The weight of participants was measured using a calibrated weighing machine (Aesthesiometer). Participants were instructed to remove heavy clothing, shoes, and accessories before stepping onto the weighing scale. They were asked to stand upright and still, ensuring their weight was evenly distributed on both feet. The weight was recorded to the nearest 0.1 kg. Height was measured using a stadiometer. Participants were asked to remove their shoes and any headwear that could interfere with accurate measurement. They stood upright with their heels together, ensuring their back, shoulders, and head were in contact with the stadiometer's vertical surface. The head was positioned such that the Frankfurt plane (a horizontal line from the ear canal to the lower edge of the eye socket) was parallel to the floor. The movable headpiece was gently lowered until it touched the crown of the participant's head without pressing. Height was recorded to the nearest 0.1 cm (Pourghasem et al., 2016). Body Mass Index (BMI) was calculated by dividing body weight (kg) by the square of height (m²). The following classification of BMI was followed: BMI below 18.5 indicates underweight, a BMI between 18.5 and 24.9 is considered normal weight, a BMI between 25 and 29.9 is categorized as overweight, and a BMI of 30 or greater is classified as obese [19] (Pourghasem et al., 2016).

The foot assessment was conducted using two tests: the Navicular Drop Test (NDT) and the Jack's Toe Raising Test (JTRT). Participants were considered to have flexible flat feet only if they tested positive on both assessments.

The NDT assesses the degree of foot pronation by measuring the displacement of the navicular bone between the subtalar joint's neutral position and relaxed standing. Participants were seated on a chair with their feet flat on the floor. The examiner palpated the medial longitudinal arch to locate the navicular tuberosity, and a dot was marked at the most prominent part of the navicular tuberosity. A card was placed vertically against the medial side of the foot, and the height of the marked navicular tuberosity from the floor was measured in the subtalar neutral position. Then participants were asked to stand in a relaxed position, and the height of the navicular tuberosity from the floor was measured again. The difference in height between the two positions (neutral and relaxed standing) was recorded as the navicular drop. A drop greater than 10 mm was considered positive for excessive pronation (D M Brody, 1982). The Navicular Drop test has demonstrated an excellent intrarater and interrater reliability (>0.880) and significant correlations with arch angle (0.643), Staheli index (0.633) and

Chippaux-Smirak index (0.614) in the assessment of flat feet (Zuil-Escobar et al., 2018).

To ensure flat feet were of flexible in nature and avoid likelihood of misclassification, Jack's Toe Raising test was used as a secondary assessment tool. Flexibility of the medial longitudinal arch is tested by observing arch formation upon dorsiflexion of great toe. Participants stood barefoot, with equal weight on both feet. The examiner gently dorsiflexed the participant's big toe (hallux) to approximately 30° while observing the medial longitudinal arch. A positive test was noted if the medial longitudinal arch reformed or lifted during the dorsiflexion maneuver, indicating flexibility. If the arch remained collapsed, the test was considered negative. This test has been reported to effectively detect flexible flat feet, making it a reliable and essential component in distinguishing between flexible and rigid flat foot deformities (Mosca, 2010). Furthermore, the test has demonstrated strong psychometric properties. Studies have reported excellent reliability, with intraclass correlation coefficients (ICCs) ranging from 0.928 to 0.999, as well as perfect sensitivity and specificity, supporting its validity as a clinical tool for diagnosing functional hallux limitus related to foot posture (Sánchez-Gómez et al., 2020).

Participants were classified as having flexible flat feet only if they tested positive on both the Navicular Drop Test (drop >10 mm) and Jack's Toe Raising Test (arch reformation upon dorsiflexion).

Investigating researchers conducted three practice trials for BMI measurement and foot assessment procedures prior to the start of the study. This was done to ensure familiarity with the methods, enhance procedural consistency, and minimize errors during the actual data collection process.

Statistical analysis

The data was analyzed using the Statistical Package for Social Science (SPSS), version 20 for Windows. Demographic data, including participants' age, were summarized using means and standard deviations. Age groups (19, 20, 21, 22, 23, 24, and 25 years) and gender distribution were analyzed and presented as frequencies and percentages. BMI was summarized as means and standard deviations for males, females, and the total sample. Participants were further categorized into four BMI groups (underweight, normal, overweight, and obese), with frequencies and percentages reported for each gender. The presence of flat feet among the 190 participants was reported as frequencies and percentages.

The association between flexible flat feet (right, left, and bilateral) and BMI categories was initially analyzed using the Chi-Square Test of Independence. Assumptions of the Chi-square test were checked, and when more than 20% of cells had expected frequencies less than 5 (particularly in cases like bilateral flat feet), Fisher's Exact Test was used to ensure valid statistical interpretation. A p-value of <0.05 was considered statistically significant. For each association, effect size was assessed using Cramer's V to evaluate the strength of association. According to commonly used guidelines, Cramer's V values of 0.1, 0.3, and 0.5 indicate small, medium, and large effect sizes, respectively.

RESULTS

Demographic data

A total of 190 undergraduate students participated, with a mean age of 21.28 ± 1.32 years. Most participants were female (n = 127, 66.8%), while males comprised 33.2% (n = 63). Table 1, provides the detailed demographic characteristics, including age distribution.

Body Mass Index (BMI)

Table 2 presents the BMI categories, summarized by frequencies and percentages. The mean BMI of participants was 23.52 ± 4.81 kg/m², with males at 23.86 ± 3.87 kg/m² and females at 23.35 ± 5.22 kg/m². Most participants (56.8%) were in the normal BMI category, followed by overweight (20.6%), obese (11.5%), and underweight (11.1%).

Prevalence of Flexible flat feet by side and gender

Among the participants, 26.3%(n=50) tested positive for FFF. 20.0% (n = 38) tested positive for FFF on the left side, and 18.4% (n = 35) on the right side. Bilateral FFF were observed in 12.1% (n = 23) of the participants. Table 3 summarizes the frequency and percentage of participants found positive for flexible flat feet by side and gender.

Association between flat feet and BMI

The relationship between flexible flat feet (right, left, and bilateral) and BMI was analyzed using Fisher's Exact Test, as the assumption for the Chi-square test was violated ($\geq 25\%$ of expected cell counts were less than 5). The analysis revealed no statistically significant association between BMI and any type of flexible flat feet. For the right foot, the association was not significant (Fisher's Exact Test, p = 0.222; Cramer's V = 0.152), indicating a small effect size. Similarly, the left foot also showed no

significant association (Fisher's Exact Test, p = 0.093; Cramer's V = 0.180), suggesting a small effect size. For bilateral flexible flat feet, the result remained non-significant (Fisher's Exact Test, p = 0.758; Cramer's V = 0.091), with a very small effect size. The results of association between FFF and BMI are summarised in Table 4. These findings suggest that BMI may not be a key factor influencing the presence of flexible flat feet, and other biomechanical or environmental variables may play a more substantial role.

Table 1: Demographic characteristics of participants

Variables	Frequency	Percentage (%)
Age (mean \pm SD = 21.28 \pm 1.32)		
19	26	13.7
20	30	15.8
21	22	11.6
22	98	51.6
23	9	4.7
24	2	1.1
25	2	1.1
26	1	0.5
Total	190	100.0
Gender		
Male	63	33.2
Female	127	66.8
Total	190	100.0

Table 2: Distribution of Body Mass Index (BMI) categories among participants

Variables	Males (n=63)	Females (n=127)	Total (n=190)
BMI, mean \pm SD (kg/m ²)	23.86 \pm 3.87	23.3 \pm 5.22	23.52 \pm 4.81
Category of Underweight	3 (1.6)	18 (9.5)	21 (11.1)
BMI, n(%), Normal (kg/m ²)	34 (17.9)	74 (38.9)	108 (56.8)
Overweight	21 (11.1)	18 (9.5)	39 (20.6)
Obese	5 (2.6)	17 (8.9)	22 (11.5)

SD-Standard deviation, BMI-Body mass index

Table 3: Frequency and percentage of flexible flat feet by side and gender

Side	Interpretation of foot assessment	Male (n=63)	Female (n=127)	Total (n=190)
FFF	Left Positive	14 (22.2)	24 (18.9)	38 (20.0)
Side, n(%)	Negative	49 (77.8)	103 (81.1)	152 (80.0)
FFF	Right Positive	10 (15.9)	25 (19.7)	35 (18.4)
Side, n(%)	Negative	53 (84.1)	102 (80.3)	155 (81.6)
Bilateral FFF, n(%)		6 (3.2)	17 (8.9)	23 (12.1)
Overall	Positive	18(28.6)	32(25.2)	50(26.3)
FFF*(any side), n(%)	Negative	45(71.4)	94(74.0)	139 (73.2)

FFF- Flexible flat feet

*Overall FFF (any side) represents participants who tested positive for flat feet on either foot or both feet (i.e., counted once per individual)

Table 4: Association between flexible flat feet (Right, Left, and Bilateral) and Body Mass Index (BMI)

Side	N (valid cases)	χ^2 (df)	Fisher's Exact p	Cramer's V	Interpretation
Right FFF	190	4.364* (3)	0.222	0.152	No significant association; weak effect size
Left FFF	190	6.152* (3)	0.093	0.180	No significant association; weak effect size
Bilateral FFF	190	1.561** (3)	0.758	0.091	No significant association; weak effect size

FFF- Flexible flat feet

χ^2 (df)-Chi-square statistic with degrees of freedom

*2 cells (25%) have expected counts <5

**3 cells (37.5%) have expected counts <5

DISCUSSION

This study investigated both the prevalence of flexible flat feet and its association with body mass index (BMI) among university students. Flexible flat feet were identified in 26.3% of participants. 20.0% tested positive on the left side, 18.4% on the right side, and 12.1% bilaterally.

The observed prevalence in this study aligns with several previous investigations in similar age groups. Abaraogu et al. (2016) reported a prevalence of 20% among adults aged 18–25 years, while Aenumulapalli et al. (2017) found a slightly lower prevalence of 13.6% in the 18–21 age group. However, Nakhanakhup and Ingkatecha (2014) reported a substantially higher prevalence of 78%, which may reflect differences in methodology, population characteristics, or assessment criteria. These variations highlight the importance of standardizing assessment tools and considering demographic influences when interpreting prevalence data

No significant associations were found for any condition: right flexible flat feet ($p = 0.222$), left flexible flat feet ($p = 0.093$), and bilateral flexible flat feet ($p = 0.758$). These findings suggest that BMI may not significantly influence foot structure in this population. Other factors, such as genetics, physical activity, and footwear habits, may play a larger role. This study adds to the limited literature on this relationship in young adults, compared to pediatric and older adult populations.

The absence of a significant association between BMI and flexible flat feet may be attributed to the multifactorial nature of foot posture, which is influenced by various factors beyond body weight. Young adults typically have more stable foot structures, and the BMI range in this group may not have been extreme enough to impact arch

mechanics. Therefore, BMI alone may not serve as a reliable indicator for flat foot posture in this demographic.

Previous studies investigating the relationship between BMI and flexible flat feet have yielded mixed results, in both pediatric populations and adult populations. For instance, a study on subjects aged 2 to 14 years found that excess weight influenced foot morphology, with flat feet being more prevalent among overweight children (Mauch et al., 2008). Similarly, another researcher reported an altered foot growth pattern in overweight children aged 6 to 12 years compared to those with normal weight (Jiménez-Ormeño et al., 2013).

In contrast, some studies have reported no significant association between BMI and foot posture among adolescents aged 10 to 14 years (Carvalho et al., 2017). Similar findings were reported in younger age groups, including children aged 3 to 15 years and 7 to 10 years, where no relationship was observed between BMI and foot posture (Evans, 2011; Evans & Karimi, 2015).

A notable observation across these studies is that those reporting a positive relationship between BMI and flat feet predominantly included participants below 10 years of age, whereas studies reporting no association tend to focus on older children and adolescents. This age-related trend is intriguing and suggests that age might play a moderating role in the relationship between BMI and foot posture. Evidence from previous studies supports the notion that foot posture undergoes significant changes during development. For instance, younger children are more likely to exhibit pronated feet due to the ongoing development of the longitudinal arch, and a U-shaped relationship between age and foot posture has been described (Staheli, 1987). These findings suggest the influence of age-related changes on foot structure,

although the precise mechanisms remain unclear and warrant further investigation.

While insights from studies on children and adolescents provide valuable context for understanding how BMI may influence foot structure during growth and development, these findings cannot be directly extrapolated to adults. Unlike children, whose feet are still developing and adapting to weight-bearing demands, adults have fully matured foot structures that are less susceptible to the biomechanical changes associated with growth. Given these distinctions, the present study aimed to explore the relationship between BMI and foot posture in adults, addressing gaps in the literature and clarifying how body weight affects foot mechanics.

As discussed earlier, the present study did not find any significant association between BMI and flat feet among adults aged between 19–26 years. These findings align with previous research conducted in adult populations and reported no association between presence of flat foot or high arched foot and BMI in community individuals aged 18 to 83 years (Atamtürk, 2009). Additionally, the study observed a decline in the prevalence of both flat feet and high-arched feet with increasing age. Similarly, a study focusing on 18–23-year-old medical students, a demographic comparable to the present study, also found no significant association between obesity and flat feet (Ramos et al., 2021).

Interestingly, some studies have highlighted age-dependent variations in the relationship between BMI and flat feet. For instance, a study reported significant correlation between BMI and flat feet in 12–15-year-olds, but this correlation disappeared in older adolescents aged 16–17 years (Daneshmandi et al., 2009). Likewise, another study on adolescents found no correlation between flat feet and variables like weight and height (Feridun Cilli, 2009). However, contrasting evidence exists. Some authors have reported a significant correlation between BMI and flat feet in adults aged 18–25 years (Chougala et al., 2015). Similar results were observed with significant association within the 18–22-year age group (Mallashetty et al., 2019).

These divergent findings highlight the complexity of the relationship between BMI and foot structure. When considering studies among adults, the majority report no significant relationship between BMI and flat feet. Supporting this observation, a meta-analysis comprising 1,648 participants with a mean age of 42.3 years (range: 3–96 years) found no evidence of a relationship between the Foot Posture Index (FPI) and BMI (Redmond et al., 2008).

A critical distinction noted by authors of present study is that many studies reporting positive associations used footprint-based methods to assess flat feet. This may have been influenced by the adiposity of the feet, as suggested by previous research indicating that increased BMI can affect arch index values, acting as a confounding factor in footprint assessments (Wearing et al., 2004). The effect of the fat pad on the plantar aspect of the foot in children and younger populations may contribute to the positive correlation between BMI and foot posture observed in studies using footprint methods. This hypothesis is further supported by research employing podoscopic examination, which revealed a statistical correlation between adiposity and the medial longitudinal arch (MLA) (Woźniacka et al., 2013). This suggests that the influence of body fat on foot structure may differ across age groups, particularly in children and adolescents, where foot development is ongoing. In contrast, the present study was conducted on adults aged 19 to 26 years, where the chances of fat pad are minimal. It employed the navicular drop test, a reliable indicator of flat feet, and Jack's toe raise test as an additional criterion. These tests are less likely to be influenced by body composition compared to footprint assessments, which could explain the discrepancies between the findings of the present study and studies reporting positive relationships.

The current study acknowledges the limitation, that it was conducted as a preliminary, single university campus cross-sectional investigation and employed non-probability convenience sampling and thus may not fully represent the general population of young adults in Malaysia. This approach was selected due to financial and time constraints. Also, the demographic composition (including ethnicity and academic background) of participants was not stratified. As such, location bias may limit the generalizability of findings to other regions or populations in Malaysia. Additionally, several potential confounding factors such as physical activity level, type of footwear, and lifestyle habits were not measured or controlled for. These variables could influence foot posture and may interact with BMI in complex ways.

Given the limitations of the current study and the interpretations drawn from both its findings and previous research, the ongoing inconsistencies in the literature highlight the need for larger, more methodologically robust studies to better understand the relationship between BMI and flat feet. Future research should aim to address these methodological limitations by employing probability based sampling, including more diverse and representative populations, and considering potential confounding factors such as physical activity levels, footwear habits, and gender differences. Additionally,

longitudinal designs may help clarify causality and provide deeper insight into how BMI may influence foot posture across different age groups and ethnic backgrounds.

CONCLUSION

This study examined the relationship between BMI and flexible flat feet in adults aged 19–26 years, finding no significant association. These results align with adult studies but contrast with research in children, possibly due to methodological differences and developmental factors. These findings suggest that BMI alone may not be a sufficient screening factor for flat feet among adults significantly influence adult foot structure, as other biomechanical or lifestyle-related factors may play a more significant role influencing the foot structure. The use of non-probability convenience sampling limits generalizability, therefore future studies should use larger samples and confounding variables to clarify this relationship. These findings may guide clinicians to adopt a more comprehensive assessment approach when evaluating adult foot posture.

ETHICS

Ethical approval for this study was obtained from the IIUM Research Ethics Committee (IREC) (reference no.: IIUM/504/14/11/2/IREC 2024-KAHS/DPRS07; Date: November 22, 2024)

ACKNOWLEDGEMENT

This study did not receive any funding.

REFERENCES

- Abaraogu, U. O., Onyeka, C., Ucheagwu, C., & Ozioko, M. (2016). Association between flatfoot and age is mediated by sex: A cross-sectional study. *Polish Annals of Medicine*, 23(2), 141–146. <https://doi.org/10.1016/j.poamed.2016.02.006>
- Aenumulapalli, A., Kulkarni, M. M., & Gandotra, A. R. (2017). Prevalence of flexible flat foot in adults: A cross-sectional study. *Journal of Clinical and Diagnostic Research*, 11(6), AC17–AC20. <https://doi.org/10.7860/JCDR/2017/26566.10059>
- Anvita Telang & Supriya Dhumale. (2020). Comparison of Core Stability in Individuals with Flexible Flat Foot and Normal Foot. *International Journal of Science and Research*, 9, 1232–1243.
- Atamtürk, D. (2009). Relationship of flatfoot and high arch with main anthropometric variables. *Acta Orthopaedica et Traumatologica Turcica*, 43(3), 254–259. <https://doi.org/10.3944/AOTT.2009.254>
- Bhaskara Rao, U., & Joseph, B. (1992). The influence of footwear on the prevalence of flat foot. A survey of 2300 children. *Journal of Bone and Joint Surgery - Series B*, 74(4), 525–527. <https://doi.org/10.1302/0301-620x.74b4.1624509>
- Carvalho, B. K. G. de, Penha, P. J., Penha, N. L. J., Andrade, R. M., Ribeiro, A. P., & João, S. M. A. (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(1), 1–7. <https://doi.org/10.1186/S13047-016-0183-0/TABLES/5>
- Chougala, A., Phanse, V., Khanna, E., & Panda, S. (2015). Screening of body mass index and functional flatfoot in adult: an observational study. *Int J Physiother Res*, 3(3), 1037–1078. <https://doi.org/10.16965/ijpr.2015.133>
- D M Brody. (1982). Techniques in the evaluation and treatment of the injured runner - PubMed. *The Orthopedic Clinics of North America*, 13(3), 541–548. <https://pubmed.ncbi.nlm.nih.gov/6124922/>
- Daneshmandi, H., Rahnema, N., & Mehdizadeh, R. (2009). Relationship between Obesity and Flatfoot in High-school Boys and Girls. *International Journal of Sports Science and Engineering.*, 3(1), 43–49.
- Elataar, F. F., Abdelmajeed, S. F., Abdellatif, N. M. N., & Mohammed, M. M. (2020). Core muscles' endurance in flexible flatfeet: A cross-sectional study. *J Musculoskelet Neuronal Interact*, 20(3), 404–410. <http://www.ismni.org>
- Evans, A. M. (2011). The paediatric flat foot and general anthropometry in 140 Australian school children aged 7 - 10 years. *Journal of Foot and Ankle Research*, 4(1), 12. <https://doi.org/10.1186/1757-1146-4-12>
- Evans, A. M., & Karimi, L. (2015). The relationship between paediatric foot posture and body mass index: do heavier children really have flatter feet? *Journal of Foot and Ankle Research*, 8(1). <https://doi.org/10.1186/S13047-015-0101-X>
- Feridun Cilli, O. P. K. K. M. M. M. K. (2009). Prevalence of flatfoot in Turkish male adolescents. *Joint Diseases & Related Surgery*, 20(2), 90–92.

- <https://pubmed.ncbi.nlm.nih.gov/19619112/>
- Halabchi, F., Mazaheri, R., Mirshahi, M., & Abbasian, L. (2013). Pediatric Flexible Flatfoot; Clinical Aspects and Algorithmic Approach. *Iranian Journal of Pediatrics*, 23(3), 247–260. <https://pmc.ncbi.nlm.nih.gov/articles/PMC3684468/>
- Jiménez-Ormeño, E., Aguado, X., Delgado-Abellán, L., Mecerreyes, L., & Alegre, L. M. (2013). Foot morphology in normal-weight, overweight, and obese schoolchildren. *European Journal of Pediatrics*, 172(5), 645–652. <https://doi.org/10.1007/S00431-013-1944-4>
- Joseph, V. S. B. (1995). The influence of footwear on the prevalence of flat foot a survey of 1846 skeletally mature persons. *THE JOURNAL OF BONE JOINT SURGERY. British Volume*, 77, 254–257.
- Khamis, S., Dar, G., Peretz, C., & Yizhar, Z. (2015). The Relationship between Foot and Pelvic Alignment while Standing. *Journal of Human Kinetics*, 46(1), 85–97. <https://doi.org/10.1515/hukin-2015-0037>
- Mallashetty, N., Itagi, V., & Vikas, N. M. (2019). Effect of body weight on arches of foot-a correlative study between BMI and arch index. *International Journal of Anatomy and Research*, 7(3), 6877–6881. <https://doi.org/10.16965/IJAR.2019.248>
- Mauch, M., Grau, S., Krauss, I., Maiwald, C., & Horstmann, T. (2008). Foot morphology of normal, underweight and overweight children. *International Journal of Obesity* (2005), 32(7), 1068–1075. <https://doi.org/10.1038/IJO.2008.52>
- Mosca, V. S. (2010). Flexible flatfoot in children and adolescents. *Journal of Children's Orthopaedics*, 4(2), 107–121. <https://doi.org/10.1007/S11832-010-0239-9>
- Nakhanakhup, C., & Ingkatecha, O. (2014). Prevalence of Flatfoot in Collegiate Students, Thailand. *Australian Journal of Basic and Applied Sciences*, 8(24), 260–263. www.ajbasweb.com
- Neumann, D. A. ., Kelly, E. Roen., Kiefer, C. L. ., Martens, Kimberly., & Grosz, C. M. . (2017). *Kinesiology of the musculoskeletal system : foundations for rehabilitation* (3rd ed.). Elsevier.
- Pourghasem, M., Kamali, N., Farsi, M., & Soltanpour, N. (2016). Prevalence of flatfoot among school students and its relationship with BMI. *Acta Orthopaedica et Traumatologica Turcica*, 50(5), 554–557.
- <https://doi.org/10.1016/J.AOTT.2016.03.002>
- Ramos, A., Fernandes, S., Pooja, Panicker, P. J., & Krishnan, P. (2021). Assessment of flat foot using plantar arch index in young adults. *Biomedicine (India)*, 41(3), 535–538. <https://doi.org/10.51248/.V41I3.649>
- Redmond, A. C., Crane, Y. Z., & Menz, H. B. (2008). Normative values for the Foot Posture Index. *Journal of Foot and Ankle Research*, 1(1), 6. <https://doi.org/10.1186/1757-1146-1-6>
- Rockar, P. A. (1995). The subtalar joint: anatomy and joint motion. *The Journal of Orthopaedic and Sports Physical Therapy*, 21(6), 361–372. <https://doi.org/10.2519/JOSPT.1995.21.6.361>
- Sánchez-Gómez, R., Becerro-de-Bengoa-Vallejo, R., Losa-Iglesias, M. E., Calvo-Lobo, C., Navarro-Flores, E., Palomo-López, P., Romero-Morales, C., & López-López, D. (2020). Reliability Study of Diagnostic Tests for Functional Hallux Limitus. *Foot and Ankle International*, 41(4), 457–462. https://doi.org/10.1177/1071100719901116/SUPPL_F ILE/FAI901116_DISCLOSURES.PDF
- Senadheera, V. V. (2016). Prevalence and Associated Factors of Flatfoot among 6 to 10 Aged Children in Central Province of Sri Lanka. *International Journal of Physiotherapy*, 3(3), 310–315. <https://doi.org/10.15621/IJPHY/2016/V3I3/100834>
- Staheli, L. T. , C. D. E. , & C. M. (1987). The longitudinal arch. A survey of eight hundred and eighty-two feet in normal children and adults. *The Journal of Bone and Joint Surgery*, 69(3), 426–428. <https://pubmed.ncbi.nlm.nih.gov/3818704/>
- Troiano, G., Nante, N., & Citarelli, G. L. (2017). Pes planus and pes cavus in Southern Italy: a 5 years study. *Annali Dell'Istituto Superiore Di Sanita*, 53(2), 142–145. https://doi.org/10.4415/ANN_17_02_10
- V, A. P., & Roshan, P. (2021). Relationship between Core Endurance and Flat Foot Among College Students. *IOSR Journal of Sports and Physical Education (IOSR-JSPE)*, 8(4), 36–40. <https://doi.org/10.9790/6737-08043640>
- Vijayakumar, K., kumar, Dr. S. S., & Subramanian, Dr. R. (2016). A study on relationship between BMI and prevalence of flat foot among the adults using foot print parameters. *International Journal of Advanced Research*, 4(5), 1428–1431. <https://doi.org/10.21474/IJAR01/467>

- Viseux, F. J. F. (2020). The sensory role of the sole of the foot: Review and update on clinical perspectives. *Clinical Neurophysiology*, 50(1), 55–68. <https://doi.org/10.1016/J.NEUCLI.2019.12.003>
- Wearing, S. C., Hills, A. P., Byrne, N. M., Hennig, E. M., & McDonald, M. (2004). The arch index: a measure of flat or fat feet? *Foot & Ankle International*, 25(8), 575–581. <https://doi.org/10.1177/107110070402500811>
- Woźniacka, R., Bac, A., Matusik, S., Szczygieł, E., & Ciszek, E. (2013). Body weight and the medial longitudinal foot arch: high-arched foot, a hidden problem? *European Journal of Pediatrics*, 172(5), 683–691. <https://doi.org/10.1007/S00431-013-1943-5>
- Zuil-Escobar, J. C., Martínez-Cepa, C. B., Martín-Urrialde, J. A., & Gómez-Conesa, A. (2018). Medial Longitudinal Arch: Accuracy, Reliability, and Correlation Between Navicular Drop Test and Footprint Parameters. *Journal of Manipulative and Physiological Therapeutics*, 41(8), 672–679. <https://doi.org/10.1016/J.JMPT.2018.04.001>