Int. J Med. Pharm. Res.
E-ISSN: 2958-3683 | **P-ISSN**: 2958-3675
Available on: https://ijmpr.in/

International Journal of
Medical and Pharmaceutical Research

ORGINAL ARTICLE OPEN ACCESS

Foot Arch Index in Different Age Groups: A Clinical Anatomical Study

Dr. A. Gangadhar Reddy[1]; Dr Rupali Muthal[2]; Dr Rupa Balihallimath[3]

[1]1 Assistant professor, Department of Anatomy, Santhiram Medical college Nandyal,Andhra Pradesh, India
[2] Associate Professor, Department of Anatomy, Bharatratna Atalbihari Vajpayee Medical College, Pune, Maharashtra, India.
[3] Assistant Professor, Department of Anatomy, KH Patil Institute of Medical Sciences. Gadag, Karnataka, India.

OPEN ACCESS

*Corresponding Author:

Dr Rupa Balihallimath
Assistant Professor, Anatomy Department, KH Patil Institute of Medical Sciences. Gadag, Karnataka, India

Received: 10-07-2025
Accepted: 13-08-2025
Available Online: 30-08-2025

A B S T R A C T

Background: The medial longitudinal arch of the foot plays a vital role in weight distribution and locomotion. The Foot Arch Index (FAI) provides a reliable measure of arch morphology across populations. Understanding age-related variations in FAI is important for clinical assessment and management of foot disorders.

Material and Methods: This cross-sectional observational study included 240 participants stratified into three groups: Group I (6–15 years), Group II (16–40 years), and Group III (41–65 years), with 80 individuals in each. Footprints were obtained using the inked footprint method under full weight-bearing. The FAI was calculated as the ratio of the area of the middle third of the footprint to the total footprint area, excluding the toes. Arch types were classified as high (<0.21), normal (0.21–0.26), or flat (>0.26). Statistical analysis was performed using one-way ANOVA with $p < 0.05$ considered significant.

Results: Children in Group I demonstrated the highest mean FAI (0.28 ± 0.05), while young adults in Group II exhibited the lowest values (0.24 ± 0.04), indicating better developed arches. Middle-to-older adults (Group III) showed intermediate values (0.26 ± 0.05). The differences among groups were statistically significant ($p < 0.001$). Distribution analysis revealed that flat arches were most common in children (62.5%), normal arches predominated in young adults (55.0%), and older adults showed a mixed pattern with nearly equal proportions of flat (47.5%) and normal arches (41.3%). High arches were relatively uncommon across all groups, with the highest prevalence observed in young adults (17.5%).

Conclusion: The study demonstrates that foot arch morphology evolves with age, showing flattening in children, maturation in young adults, and partial decline in older adults. These findings highlight the importance of age-specific evaluation of foot arch in clinical and anatomical assessments.

Key words: Foot Arch Index, Flat Foot, Age-related changes, Footprint analysis, Arch morphology

INTRODUCTION

The medial longitudinal arch (MLA) of the foot is a critical structure that contributes to load distribution and shock absorption during weight-bearing activities. Variations in MLA morphology, such as flat or high arches, can influence gait patterns and predispose individuals to musculoskeletal disorders [1]. The Foot Arch Index (FAI), introduced by Cavanagh and Rodgers in 1987, quantifies arch morphology by calculating the ratio of the middle third area of a footprint to the total footprint area, excluding the toes. This method provides a reliable and reproducible measure of foot arch type [2].

Age-related changes in foot structure have been documented, with studies indicating that older adults often exhibit flatter feet compared to younger populations [1]. These alterations may be attributed to factors such as ligamentous laxity, decreased muscle strength, and changes in body mass distribution. For instance, a study by Menz et al. (2005) reported that older individuals tend to have reduced arch height and increased foot width, which are associated with increased risk of foot pain and disability [1].

Furthermore, research has shown that the prevalence of flat feet decreases with age during childhood, suggesting a developmental progression towards a more stable arch [4]. A study by Menz et al. (2012) found that children aged 6–10 years had a higher incidence of flat feet, which decreased as they approached adolescence [3].

Understanding the variations in foot arch morphology across different age groups is essential for developing age-specific interventions and footwear recommendations [5,6]. The present study aims to investigate the distribution of foot arch types in children, young adults, and older adults using the FAI, providing insights into the developmental and degenerative changes of the foot arch.

MATERIAL AND METHODS

This cross-sectional, observational study was carried out in the Department of Anatomy of a tertiary care medical teaching hospital. A total of 240 participants were recruited, stratified into three age groups: Group I (6–15 years), Group II (16–40 years), and Group III (41–65 years), with 80 individuals in each group. The sample size was determined considering previous literature on foot morphology and allowing for adequate statistical comparison between age categories. Participants were selected using a simple random sampling technique from students, staff, and patients' attendants who fulfilled the inclusion criteria.

Inclusion criteria comprised healthy individuals with no history of congenital or acquired foot deformities, trauma, or systemic musculoskeletal disorders. Subjects with prior foot surgery, chronic inflammatory diseases, or metabolic conditions affecting bone or soft tissue were excluded. Written informed consent was obtained from all adult participants, while consent and assent were secured for minors.

Procedure:

Footprints were recorded using the inked footprint method. Each subject was instructed to wash and dry both feet, after which they stepped on an ink-smeared sponge sheet placed over a white paper, ensuring full weight-bearing in an upright posture. The prints were allowed to dry and subsequently analyzed.

The Foot Arch Index (FAI) was calculated as described by Cavanagh and Rodgers [2, Figure 1]. Each participant provided an inked footprint in a standing position with full weight-bearing. The footprint (excluding the toes) was divided into three equal regions—anterior, middle, and posterior. The area of the middle third was measured and then divided by the total footprint area to obtain the FAI value. An FAI value <0.21 was considered indicative of a high arch, 0.21–0.26 as normal, and >0.26 as flat arch. Measurements were made independently by two observers, and the average values were used for analysis to reduce inter-observer variability.

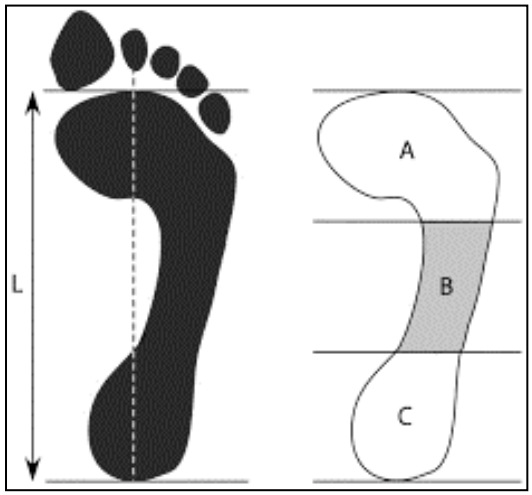

Figure 1: Foot Arch Index (FAI) calculation [3]

Statistical analysis was performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as mean ± standard deviation. Differences between groups were evaluated using one-way ANOVA followed by post-hoc Tukey test. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1 summarizes the demographic profile of the study participants. The mean age in Group I was around 11 years, whereas Group II and Group III represented young and middle-to-older adults with mean ages of approximately 27 and 53 years, respectively. The gender distribution was nearly balanced across all groups, with a slight male predominance overall. Body mass index (BMI) showed a progressive rise with advancing age, ranging from a mean of 18 kg/m² in children to over 25 kg/m² in the older adult group, indicating an age-related increase in body habitus.

Table 1. Baseline Characteristics of Study Participants (N = 240)

Variable	Group I (6–15 yrs, n=80)	Group II (16–40 yrs, n=80)	Group III (41–65 yrs, n=80)	Total (N=240)
Age (years), mean ± SD	11.2 ± 2.6	27.4 ± 6.2	52.6 ± 7.1	30.4 ± 16.2
Male : Female	41 : 39	40 : 40	42 : 38	123 : 117
BMI (kg/m²), mean ± SD	18.2 ± 2.1	22.6 ± 3.4	25.1 ± 3.7	21.9 ± 4.1

As shown in Table 2, the mean Foot Arch Index varied significantly among the three age categories. Children (Group I) exhibited the highest mean FAI values, consistent with a predominance of flatter arches in this age group. In contrast, young adults (Group II) demonstrated significantly lower FAI scores, reflecting better developed and more stable arches. The middle-to-older adult group (Group III) showed intermediate FAI values, suggestive of a trend toward flattening with aging. Statistical analysis confirmed that the differences across groups were highly significant ($p < 0.001$).

Table 2. Foot Arch Index (FAI) in Different Age Groups

Age Group	Mean FAI ± SD	p-value*
Group I (6–15 yrs)	0.28 ± 0.05	<0.001
Group II (16–40 yrs)	0.24 ± 0.04	
Group III (41–65 yrs)	0.26 ± 0.05	

*One-way ANOVA test

The distribution of arch types is presented in Table 3. A majority of children displayed flat arches, while normal arches were most prevalent among young adults, supporting the notion of arch maturation during adolescence and early adulthood. Interestingly, older adults demonstrated a mixed pattern, with nearly equal proportions of flat and normal arches, along with a modest frequency of high arches. High-arched feet were least common across all groups but were relatively more frequent in young adults compared with children. Overall, the findings indicate that the medial longitudinal arch undergoes developmental strengthening during youth but tends to decline again with aging.

Table 3. Distribution of Foot Arch Types across Age Groups

Foot Arch Type	Group I (n=80)	Group II (n=80)	Group III (n=80)	Total (N=240)
High Arch (<0.21)	5 (6.3%)	14 (17.5%)	9 (11.3%)	28 (11.7%)
Normal Arch (0.21–0.26)	25 (31.3%)	44 (55.0%)	33 (41.3%)	102 (42.5%)
Flat Arch (>0.26)	50 (62.5%)	22 (27.5%)	38 (47.5%)	110 (45.8%)

DISCUSSION

Our study observed significant variations in the Foot Arch Index (FAI) across different age groups, aligning with existing literature that highlights age-related changes in foot morphology. Children exhibited the highest mean FAI, indicating flatter arches, while young adults demonstrated the lowest mean FAI, suggesting more developed arches. Older adults showed intermediate FAI values, consistent with a trend toward arch flattening with aging. These findings corroborate previous studies that have reported similar age-related changes in foot arch structure [7].

The distribution of arch types in our study further supports these observations. A higher prevalence of flat arches was noted in children, while normal arches were most prevalent among young adults. Older adults exhibited a mixed

pattern, with nearly equal proportions of flat and normal arches, and a modest frequency of high arches. This distribution is consistent with findings from other studies that have documented similar patterns in foot arch types across different age groups [7,8].

The observed age-related changes in foot arch morphology may be attributed to several factors. In children, the development of the arch is a dynamic process influenced by genetic, environmental, and mechanical factors [9,10]. As children grow, the soft tissues and bones of the foot undergo maturation, leading to the formation of a more defined arch. In young adults, the arch reaches its peak development, providing optimal support for weight-bearing activities. However, with advancing age, degenerative changes such as ligamentous laxity, decreased muscle strength, and changes in body mass distribution can contribute to arch flattening [11-13].

Our study's findings underscore the importance of considering age-specific variations in foot arch morphology when assessing foot health and designing interventions. Understanding these age-related changes can aid in the development of targeted strategies to prevent and manage foot-related disorders across the lifespan.

CONCLUSION

The present study demonstrates that foot arch morphology, as assessed by the Foot Arch Index (FAI), exhibits significant variations across different age groups. Children predominantly display flatter arches, reflecting ongoing developmental changes, whereas young adults show well-formed normal arches, indicative of peak medial longitudinal arch development. Older adults exhibit a mixed pattern with partial flattening, likely due to age-related degenerative changes in soft tissues and ligaments. These findings emphasize the importance of considering age-specific differences in foot arch evaluation for clinical assessment, preventive strategies, and appropriate footwear design.

REFERENCES

1. Menz HB, Lord SR, Edwards S. Foot and ankle characteristics associated with impaired balance and functional ability in older people. J Gerontol A Biol Sci Med Sci. 2005;60(12):1546–52.
2. Cavanagh PR, Rodgers MM. The arch index: a useful measure from footprints. J Biomech. 1987;20(5):547-51. doi: 10.1016/0021-9290(87)90255-7.
3. Menz HB, Fotoohabadi MR, Wee E, Spink MJ, Landorf KB, Hill KD, et al. Visual categorisation of the arch index: a simplified measure of foot posture in older people. J Foot Ankle Res. 2012;5:10. doi:10.1186/1757-1146-5-10
4. Pfeiffer M, Kotz R, Ledl T, Hauser G, Sluga M. Prevalence of flat foot in preschool-aged children. Pediatrics. 2006 Aug;118(2):634-9. doi: 10.1542/peds.2005-2126.
5. Mauch M, Grau S, Krauss I, Maiwald C, Horstmann T. Foot morphology of normal, underweight and overweight children. Int J Obes (Lond). 2008 Jul;32(7):1068-75. doi: 10.1038/ijo.2008.52.
6. Chen KC, Tung LC, Tung CH, Yeh CJ, Yang JF, Wang CH. An investigation of the factors affecting flatfoot in children with delayed motor development. Res Dev Disabil. 2014 Mar;35(3):639-45. doi: 10.1016/j.ridd.2013.12.012.
7. Bosch K, Gerß J, Rosenbaum D. Development of healthy children's feet—Nine-year results of a longitudinal investigation of plantar loading patterns. Gait Posture. 2010 Oct;32(4):564–71. doi:10.1016/j.gaitpost.2010.08.003.
8. Chen JP, Chung MJ, Wang MJ. Flatfoot prevalence and foot dimensions of 5- to 13-year-old children in Taiwan. Foot Ankle Int. 2009 Apr;30(4):326-32. doi: 10.3113/FAI.2009.0326.
9. Gijon-Nogueron G, Martinez-Nova A, Alfageme-Garcia P, Montes-Alguacil J, Evans AM. International normative data for paediatric foot posture assessment: a cross-sectional investigation. BMJ Open. 2019 Apr 14;9(4):e023341. doi: 10.1136/bmjopen-2018-023341.
10. Mbaka GO, Adelaja M. Influence of BMI on foot posture alignment in resting gait of secondary school children in Lagos metropolis aged 10 to 18 years. Ann Afr Med Res. 2021;4(1):144. doi:10.4081/aamr.2021.144.
11. Xu L, Gu H, Zhang Y, Sun T, Yu J. Risk Factors of Flatfoot in Children: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2022 Jul 6;19(14):8247. doi: 10.3390/ijerph19148247.
12. Henry JK, Shakked R, Ellis SJ. Adult-Acquired Flatfoot Deformity. Foot Ankle Orthop. 2019 Jan 16;4(1):2473011418820847. doi: 10.1177/2473011418820847.
13. Giuca G, Marletta DA, Zampogna B, Sanzarello I, Nanni M, Leonetti D. Correlation Between the Severity of Flatfoot and Risk Factors in Children and Adolescents: A Systematic Review. Osteology. 2025; 5(2):11. https://doi.org/10.3390/osteology5020011