Original Research Paper

Volume - 13 | Issue - 04 | April - 2023 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Orthopaedics

# A STUDY ON PREVALENCE OF IDIOPATHIC FLATFOOT IN ADOLESCENTS OF NORTH EAST INDIA

**Dr. Hemjit Das** — Associate professor Department of Orthopaedics, Lakhimpur Medical College & Hospital, Lakhimpur, Assam

**Dr. Sandeep Prasad*** — Senior Resident Department of Orthopaedics, Lakhimpur Medical College & Hospital, Lakhimpur, Assam*Corresponding Author

**Dr. Mrityunjoy Gohain** — Senior Resident Department of Orthopaedics, Lakhimpur Medical College & Hospital, Lakhimpur, Assam

**ABSTRACT** **Introduction:** "Pes planus" commonly known as "flatfoot" is characterised by sagging of medial longitudinal arch with secondary hind foot valgus, forefoot abduction and supination relative to hind foot. Idiopathic type of flatfoot is physiological and there is a lack of clear consensus about the maximum limit of age for its persistence. Assessment of medial longitudinal arch can be done either on clinical grounds or based on radiological evidences. Foot prints can be easily obtained with simple ink print method. They are simple, fast, inexpensive and non-invasive way to assess the arches of foot. **Materials and methods:** The present study was conducted over a period one year under Department of Orthopaedics, Assam Medical College & Hospital. In this community based cross sectional study, 800 school going children of age group 10 to 15 years were included. Bilateral footprints of all children were taken using simple ink print method. Results and Observations: The Staheli's PAI value ≥ +2SD from the mean was regarded as threshold index for flatfoot in either feet. The cut off in left foot was PAI value ≥1.29 and for right foot it was ≥1.18 to define flatfoot. Number of children with normal foot was 704 (88%) compared to 72 children (9%) with flatfoot. 3% of children had high arched foot. **Discussion and conclusion:** There is a significant correlation in terms of persistence of flatfoot in adolescents with obesity, faulty shoe wearing practices and children belonging to higher socio-economic groups. Though flexible flatfoot is self correctable but proper cut off age by which it resolves is still a matter of debate.

**KEYWORDS :** Pes planus, Staheli's Plantar arch index(PAI) , BMI : Body mass index

## INTRODUCTION

There are vast static-postural changes in feet of young age groups. Foot is the first level of contact for the body to the ground.1 The complex anatomical structure of foot which is comprised by bones, strengthened by ligaments and tendons have led to advanced modification allowing the foot to support the weight of the body in erect balanced posture with minimum possible load. These osseo-ligamentous components form rigid structures called the "arches of foot which include the lateral longitudinal arch, the medial longitudinal arch and the transverse arch.[2]

"Pes planus" also known as "Flatfoot" is a postural deformity where the medial longitudinal arch of the foot collapses and consequently the entire sole of the foot comes into complete or partially-complete contact with the ground. This is associated with increased hindfoot eversion during weight bearing.[3,4] Flatfoot is the universally found in children when they start walking. The cause has been attributed to lack of neuromuscular control, presence of thick pad of fat in sole and Intrinsic ligamentous laxity resulting in flattening of the foot while bearing weight.[5,6,7] However, there is no such study which has precisely investigated the age when these causes of physiological flatfoot self resolve in children, though it has been assumed that midfoot plantar fat pad starts resorption after the onset of independent walking.[8]

Assessment of medial longitudinal arch (MLA) can be done either on clinical grounds or based on radiological evidences. Radiographic analysis is relatively expensive and associated radiation is a risk for children, making it difficult to apply in large population based surveys. Plantar prints can be easily obtained with the help of simple ink print method. They are simpler, quicker, inexpensive and non-invasive way to obtain morphological features of foot arches.

## MATERIALS AND METHODS

The present study was conducted over a period 1 year under Department of Orthopaedics, Assam Medical College & Hospital, Dibrugarh. In this community based cross sectional study, a total of 800 school going adolescents of age group 10 to 15 years were included. Informed consent was obtained either from the parents or the school authorities. Permission was obtained from the Institutional Ethics Committee (H), Assam Medical College & Hospital, Dibrugarh prior to the commencement of the study.

**Sample size**: As there was no available data on prevalence of idiopathic flatfoot among the adolescents of North-east India, especially in Assam, so considering the prevalence to be 50% with 95% confidence interval and 5% absolute error, the sample size was calculated to be 384. [9] Taking into account a design effect of 2.0 the sample size came out to be 768 which was rounded off to 800.The study was conducted in private and government schools of Dibrugarh. The calculated sample size was divided equally among private and government schools.

**Method:** Age was verified using records of school authorities. Modified Kuppuswamy Socioeconomic status scale was used to assess the socioeconomic status of the family. Specific enquiry was made into any previous trauma, infection, surgery of the lower limbs or family history of musculoskeletal disorders which may point to a syndrome. Height (cm) was measured with the children standing without shoes against a wall using a long measuring. Weight (Kg) was recorded using a simple weighing scale. Body mass index (BMI) was calculated as Weight/Height$^2$.The clinical examination of children started with general examination of the musculoskeletal system, gait pattern and evidences of generalized ligamentous laxity. Foot and ankle examination began with evaluation of ankle dorsiflexion and plantarflexion both with knee flexed as well as with knee in extended position. If foot dorsiflexion was less than $10^0$ it was considered to be a case of Achilles tendon contracture. $14^{-15}$ Foot inversion and eversion was checked for subtalar range of motion (ROM). Assessment of ligamentous laxity around foot and ankle was assessed by tip toe test and Jack's toe-raising test. Footwears of each students were examined separately.

Footprints of all the 800 subjects were taken using simple ink print method. A large pad of thick dressing gauze was placed in a tray and was soaked with diluted ink. Foot was placed in the tray. The foot was then immediately placed on a paper to obtain the print. The subjects were asked to stand up and perform a small flexion of the ipsilateral knee (about 30º), with the aid of the investigator and then to go back to the initial position, removing the foot from the paper.[10]

**Calculation of Staheli's Plantar Arch Index (PAI) :** The most medial edges of forefoot and hindfoot on the footprint were marked. A line was drawn joining the above two edges which was tangential to the medial aspect forefoot and the hindfoot. The mid point of this line was calculated. From this point, a perpendicular line was drawn crossing the footprint. The same procedure was repeated for heel tangency point. The points where the two lines crossed their respective regions on footprint were marked. The width of the midfoot and hindfoot

regions were measured (cm). The plantar arch index (PAI) was calculated by dividing the width of midfoot by width of hindfoot. [10,11]

**Evaluation criteria:** According to the Pediatric Orthopaedic Society a normal plantar arch index (PAI), is the one comprised within 2 standard deviations (SD) of the population average. Thus, PAI ≥ sum of 2SD from the mean was considered to be indicative of flatfoot .[10] The statistical analysis of data was performed using the computer program, Statistical Package for Social Sciences (SPSS for Windows, version 20.0. Chicago, SPSS Inc.) and Microsoft Excel 2010. Results on continuous measurements are presented as mean ± standard deviation, are compared using student t test. Discrete data are expressed as proportion and percentage and are analysed using Chi square test and Fischer's exact test (where the cell counts were <5 or 0). Pearson's correlation coefficient (r) was used to measure the associations among continuous variables. For all analyses, the statistical significance was fixed at 5% level (p value <0.05).

**Fig.1 Measurement of Height and Weight**

**Fig.3 Sagging medial arch in a flatfooted child .**

**Fig.4 Child's foot in a tray with thick gauze soaked in Ink (Left) .Obtaining static footprint on a paper ~30o flexion at knee (Right)**

**Fig.5 Footprints showing Bilateral and Unilateral flatfeet**

**Fig.6 Attrition of medial aspect of sole in a Right side flatfooted child**

## RESULTS AND OBSERVATION

A total of 800 children were randomly selected in this study from 10 to 15 years of age. The maximum number of children belonged age group of 12 years (224; 28%). The mean age of the population was 12.22 ± 1.41 years. Overall there were 372 (46.50%) males as compared The mean Staheli's plantar arch index (PAI) for left foot was 0.67 ± 0.31 and for right foot, it was 0.66 ± 0.26. PAI value ≥ +2SD from the mean was regarded as threshold index for flatfoot in either feet whereas value < -2SD was considered to be indicative of a high arched foot. The calculated cut off value in left foot was PAI value ≥1.29 and similarly for right foot, it was ≥1.18 to define flatfoot for the study population. The total number of children with normal foot in this study was 704 (88%) compared to 72 children (9%) of flatfoot. 3% of children had high arched foot. The total children with flatfoot in the study population were 72. Out of total flatfoot cases, unilateral cases (49; 68.06%) were more than bilateral cases (23; 31.94%). The right foot (26; 36.11%) was involved more than the left foot (23; 31.94%). The prevalence of flatfoot was higher (13.54%) among the children of age group of 10 years (13 cases out of 96 children). The least prevalence (1.79%) was seen in age group of 15 years (1 case out of 56 children). In our study the number of flatfoot cases were more in males (40; 55.56%) as compared to females (32; 44.44%). The difference in prevalence between two genders was not statistically significant (p = 0.413643).

The overall prevalence of flatfoot in various categories of population as per BMI was compared using chi-square test. The prevalence flatfoot among obese group (26.87%) was the highest (18 cases out of 67 obese children). This difference was statistically significant (p < 0.001).The socioeconomic status of flatfoot cases were categorised using Modified Kuppuswamy socio economic scale and comparison was done using Fisher's exact test. The maximum number of flatfoot cases (51; 12.98%) were in Lower middle (III) class. There was significant difference in flatfoot prevalence as per socioeconomic status (p <0.001).

**Table 1. Calculation of mean Staheli's plantar arch index (PAI) of total study population**

| FOOT | Staheli's PAI | | 95% Confidence Interval | |
|---|---|---|---|---|
| | Mean | ± S.D. | Lower Bound | Upper Bound |
| Left | 0.67 | 0.31 | 0.65 | 0.69 |
| Right | 0.66 | 0.26 | 0.64 | 0.68 |

**Table 2. Distribution of children based on Staheli's PAI**

| TOTAL POPULATION STUDIED | NORMAL FOOT | | FLATFOOT | | HIGH ARCH FOOT | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| 800 | 704 | 88.00 | 72 | 9.00 | 24 | 3.00 |

## DISCUSSION

The study of development of arches of foot in normal healthy children is of significant clinical importance. [12] So far there has been a matter of debate regarding the usefulness of footprint methods to detect flatfoot. Some authors do not recommend the use of footprints [13] but there are other authors who advocate its use. Staheli *et al*. [11], Engel and Staheli [14], Cavanagh and Rodgers [15], Gervis [16] and Volpon [17], Chen [18] have promoted the footprint method. Our study adopted the same footprint method to calculate Staheli's plantar arch index (PAI) with slight modification of the method adopted by Hernandez *et al*. [10] and Singrolay *et al*. 19 to assess the footprints using simple ink print method. This modification to obtain footprints was used by P. Santhanam *et al*. [20], P. Rithanya *et al*. [21], Pranati.T *et al* [22] and Kharbuja *et al*. [23], in their study. The radiological evidences have showed a significant correlation between x-ray and footprint based studies to assess arches of foot. Kanatli *et al*. [24], reported a positive correlation of PAI between lateral talo–first metatarsal angle and talo–horizontal angle on radiographs. Plumarom Y *et al*. [25], in their performed a similar study and advocated the use of footprints as screening and diagnostic tool to calculate Staheli's PAI.

The prevalence of flatfoot decreases with age. This is evident by the studies conducted by Staheli *et al* [11], who analysed footprints of 441 subjects in age groups of 1 – 80 years. Similar findings were reported from the studies of Forriol and Pascual [26] and Pfeiffer *et al*. [27] In our study, a decreasing trend in the prevalence of flatfoot was observed from younger to older age. This finding was supported by the decreasing values of mean PAI from lower to higher age .There was a negative correlation between PAI for left ®= -0.1143, p=0.0012) as well as for right (r= -0.0858, p=0.01618) foot with increasing age of the children. 13.54 % out of 96 children from age group of 10 years whereas 1.79 % out of 56 children from 15 years age group were found to be flatfooted. This finding was consistent with the literature that supports the evidence of self correctibility of flatfoot as the age progresses.

We further stratified the mean PAI values as per gender in each group. It was found that mean PAI values of males in each group was comparatively higher than the corresponding females. This points towards the fact that males are more prone to have flatfoot as compared to females of their corresponding age. [28] In our study the normal range of PAI for left foot was 0.05 to <1.29 and it was 0.14 to <1.18 for right foot. Based on the above referral range 704 children (88%) out of total study population were found to have normal arched feet whereas 24 children (3%) had high arched feet.

The PAI values ≥ +2SD from the mean were considered to be the threshold and thus flatfoot was considered. We found threshold indices for flatfoot to be 1.18 for the right foot and 1.29 for the left foot. Any value equal or above to these was indicative of flatfoot. The difference in mean PAI between sides (right and left foot) is still a point to be discussed. The reason behind this difference was unclear. In our study the gender wise threshold for each foot was closer to the overall threshold value of the total population considering either foot irrespective of age and sex. Therefore a single threshold for each foot was accepted for calculation purposes. Based on these cut-off values we calculated the prevalence of flatfoot to be 9% (4% in females and 5% in males). Though males in the study showed a higher prevalence of flatfoot which can be related to slower growth of medial longitudinal arch with thick plantar fat pads among them [8], the difference between two genders among total cases of flatfoot was not statistically significant (p=0.413643).

There has been a discrepancy in threshold values of our study with the studies conducted by other authors. The study conducted by Hernandez *et al*. in the Brazilian population had set the threshold to PAI values > 1.15 and the similar values were used in the studies conducted by P. Santhanam, *et al.* [20], P. Rithanya, *et al*. [21], Pranati.T *et al*. [22] T. Nguyen *et al*. defined pes planus for a person as having a ratio of arch width to rear-foot width of more than 75%. [29] We feel that there are significant differences in terms of race, ethinic diversity, lifestyle, genetic makeup etc between indian children with that of other countries. Thus the decision to follow the criterion laid by Pediatric Orthopaedic Society was taken and subsequently a population based mean of PAI was calculated and a unique cut off was set for both the feet separately.

A summary of few similar studies with population demography and flatfoot prevalence using Staheli's PAI are mentioned in the table below:

| AUTHORS / STUDIES | STUDY POPULATION | AGE GROUP (years) | FLATFOOT PREVALENCE (%) |
|---|---|---|---|
| Vangara et al. | 360 | 3 - 15 | 42.84 |
| P.santhanam et al | 50 | 5 - 14 | 14 |
| Kharbuja et al. | 157 | 5 - 10 | 5.1 |
| Our Study (2018–19) | 800 | 10 - 15 | 9 |

The difference in prevalence in our study as compared to other studies can be attributed to the threshold values to define flatfoot. As per literature the process of arch maturation continues till first decade of life[7], therefore inclusion of children of age group from 10 to 15 years in our study is justified to determine the prevalence of idiopathic flatfoot in this region of North-east India. There is a lack of concrete evidence which can show uptill what age the flexible variety of flatfoot persists and this is one of the reasons of conducting this type of study in our region.

Body mass index (BMI) has been considered to have an influence on medial arch as studies have shown to have higher prevalence of flatfoot in overweight and obese children. Studies of Morrison *et al*. [30], Mauch *et al* [31] and many other authors have found a significant correlation between obesity and flatfoot. In our study after categorising the BMI of the study population based on weight status, it was found that maximum percentage (26.87 %) of cases belonged to obese group. The probable explaination of this occurrence can be attributed to increased loading in obese and overweight children where as a part of compensatory mechanism the foot shifts the load to central and medial forefoot thus altering the normal configuration of foot arches. [32]

In our study the prevalence of flatfoot was more in higher socioeconomic classes which was statistically significant (p<0.001). Shoe wearing practices and lifestyle variation can be one of the contributing factors. Rao *et al*. in their cross-sectional study suggested that shoe wearing in early childhood is detrimental to developmental of longitudinal arch and discouraged the use of closed- toe shoes. [33]

Harris *et al*. in their study discussed about the cases of symptomatic flexible flatfoot. They mentioned that such cases can present with vague pain around medial aspect of foot, in the region of sinus tarsi and knee. They also concluded that consequence of flatfoot leads to gait disorders and decreased endurance.[34] Contrary to this, the cases of flatfoot detected in our study were asymptomatic and did not give any history of disability arising out of foot deformity. The need for treatment for flatfoot cases has always been a matter of debate. The opinion from various authors have never lead to a satisfactory conclusion. Viladot [35]recommended initiation of treatment at the age of 2 or 3 years. Staheli [36], observed spontaneous correction of flatfoot with advancing age and that those that remained deformed did not benefit from orthopedic treatment, Rose advocated that treatment of flatfeet should never be started after 6 years and stated that a flatfoot that is not self correctable will not be corrected with the aid of orthopedic insoles.[37] The study conducted by Evans concluded that there is a lack of clear evidence of immediate effect of orthopedic footwear or foot orthoses radiographically in case of children with flatfoot but there were evidences of improvement over time. [38] The 72 children with flatfoot in our study provide a scope to decide the controversies related to initiation of treatment for otherwise asymptommatic cases.

Our study had few limitations. One of the limitations was, since the study was based on clinical parameters, observer bias may be an issue. Secondly, a prospective cohort study would have been more meaningful and reliable.

## CONCLUSION

This study was conducted to find out the prevalence of Idiopathic flatfoot in the adolescents of north east India. The present study to our best knowledge is the largest study on North-east Indian children. Even though there are limitations in the present study, it does gives us the mean for Staheli's plantar arch index for each age group. In this study we found a significant correlation between obesity and flatfoot. This points towards adoption of preventive and rehabilitation interventions that can improve the quality of life in overweight as well as obese children. Age is yet another parameter which demands attention in our study because there was a negative correlation for prevalence of flatfoot with increasing age. This guides us to the fact that flexible flatfoot is self correctable. We hope these data will promote a sense of awareness regarding foot health among heath-care providers. This data can be used to identify children who require further follow-up and evaluation. However a truly representative sample from all parts of north east India, being the centre of diversity in terms of ethnicity, is needed to further establish and justify the findings of this study.

## REFERENCES


1. Nester C, Hutchins S, Bowker P. Shank rotation: A measure of rear foot motion during normal walking. Foot Ankle Int. 2000;21:578-83.
2. Williams P, Bannister L, Berry M, Collins P, Dyson M, Dussek J et al. Gray's Anatomy. 38th ed. New York: Churchill Livingstone. 1995. 481–3, 692-4. p.
3. Hösl M, Böhm H, Multerer C, Döderlein L. Does excessive flatfoot deformity affect function? A comparison between symptomatic and asymptomatic flatfeet using the Oxford Foot Model. Gait Posture. 2014;39(1):23–8.
4. Kothari A, Dixon PC, Stebbins J, Zavatsky AB, Theologis T. The relationship between quality of life and foot kinematics in flatfooted children. Gait Posture. 2015 Dec;42:S67.
5. Nemeth B. The diagnosis and management of common childhood orthopedic disorders. Curr Probl Pediatr Adolesc Heal Care. 2011;41(1):2-28.
6. Halabchi F, Mazaheri R, Mirshahi M, Abbasian L. Pediatric flexible flatfoot; Clinical aspects and algorithmic approach. Iran J Pediatr. 2013;23(3):247–60.
7. Labovitz JM. The algorithmic approach to pediatric flexible pes planovalgus. Clin Pod Med Surg. 2006;23(1):57-76.
8. Mickle KJ, Steele JR, Munro BJ. Is the foot structure of preschool children moderated by gender? J Pediatr Orthop. 2008;28(5):593–6.
9. Lemeshow S, Hosmer JD, Klar J, Lwanga S. Adequacy of sample size in health studies, John wiley & sons. 1990. 2,95.
10. Hernandez AJ, Kimura LK, Laraya MHF, Fávaro E. Calculation of staheli's plantar arch index and prevalence of flat feet: A study with 100 children aged 5-9 years. Acta Ortop Bras. 2007;15(2):68–71.
11. Staheli L, Chew D, Corbett M. The longituidinal arch. J Bone Jt Surg. 1987;426–8.
12. Chen YC, Lou SZ, Huang CY, Su FC. Effects of foot orthoses on gait patterns of flat feet patients. Clin Biomech. 2010;25(3):265–70.
13. Cobey J, Sella E. Standardizing methods of measurement of foot hape by including the effects of subtalar rotation. Foot Ankle. 1981;2:30–6.
14. Engel G, Staheli L. The natural history of torsion and other factors influencing gait in childhood. Clin Orthop Relat Res. 1974;99:12–7.
15. Cavanagh PR, Rodgers MM. The arch index: A useful measure from footprints. J Biomech. 1987;20(5):547–51.
16. Gervis W. Flatfoot. Br Med J. 1970;1:479–81.
17. Volpon JB. Footprint analysis during the growth period. J Pediatr Orthop. 1994;14(1):83–5.
18. Chen C, Huang M, Chen T, Weng M, Lee C, Wang G. The correlation between selected

measurements from footprint and radiograph of flatfoot. Arch Phys Med Rehabil. 2006;87:235–40.
19. Singrolay R, Singh P, Pancholi N. Study of correlation between planter arch index and BMI in children. IOSR J Dent Med Sci. 2015;14:83–6.
20. Santhanam P, Babu KY, Mohanraj KG. Determination of flat foot by footprint analysis using plantar arch index in children aged between 5 and 14 years. 2018;10(10):12–5.
21. Rithanya P, Babu KY, Mohanraj KG. Assessment of flat foot by plantar arch index using footprint in aged population. Drug Invent Today. 2018;10(11):2142–5.
22. Pranati T, Yuvraj Babu K, Ganesh K. Assessment of plantar arch index and prevalence of flat feet among south indian adolescent population. J Pharm Sci Res. 2017;9(4):490–2.
23. Kharbuja R, Dhungel S. Prevalence of pes cavus and pes planus among school going children of Bhaktapur district , Nepal. Nepal Med COll J. 2017;19(1):9–12.
24. Kanatli U, Yetkin H, Cila E. Footprint and radiographic analysis of the feet. J Pediatr Orthop. 2001;21(2):225–8.
25. Plumarom Y, Imjaijitt W, Chaiphrom N. Comparison between staheli index on harris mat footprint and talar-first metatarsal angle for the diagnosis of flatfeet. J Med Assoc Thail. 2014;97(8):S131–5.
26. Forriol F, Pascual J. Footprint Analysis Between Three and Seventeen Years of Age. Foot Ankle Int. 1990;11(2):101–4.
27. Pfeiffer M, Kotz R, Ledl T. Prevalence of flat foot in preschool-aged children. Pediatrics. 2006;118(2):634-9.
28. Chang J, Wang S, Kuo C, Shen H, Hong Y, Lin L. Prevalence of flexible flatfoot in Taiwanese school-aged children in relation to obesity, gender and age. Eur J Ped. 2010;169:447–52.
29. Nguyen U, Hillstrom H, Li W, Dufour A, Kiel D, Procter-Gray E et al. Factors associated with hallux valgus in a population-based study of older women and men: The MOBILIZE Boston study. Osteoarthr Cartil. 2010;18:41–6.
30. Morrison SC, Durward BR, Watt GF, Donaldson MDC. Anthropometric foot structure of peripubescent children with excessive versus normal body mass a cross-sectional study. J Am Podiatr Med Assoc. 2007;97(5):366–70.
31. Mauch M, Grau S, Krauss I, Maiwald C, Horstmann T. Foot morphology of normal, underweight and overweight children. Int J Obes. 2008;32(7):1068–75.
32. Hassan D, Nader R, Rahimeh M. Relationship between obesity and flatfoot in high-school boys and girls. Int J Sport Sci Eng. 2009;3(01):043–9.
33. Rao UB, Joseph B. the Influence Prevalence of Footwear of Flat on the Prevalence of Flat Foot. J Bone Jt Surg Br. 1992;74(4):525–7.
34. Harris E, Vanore J, Thomas J. Diagnosis and treatment of pediatric flatfoot. J Foot Ankle Surg. 2004;43(6):341-73.
35. Viladot A. Biomechanics of the subtalar joint. Foot. 1992;2(2):83–88 doi: 10.1016/0958-2592(92)90023-i.
36. Staheli L. Corrective shoes for children: a survey of current practice. Pediatrics. 1980;65:13–7.
37. Rose G. Flat feet in children. Br Med J. 1990;301:1330–1.
38. Evans AM, Rome K. A cochrane review of the evidence for non-surgical interventions for flexible pediatric flat feet. Eur J Phys Rehabil Med. 2011;47(1):69–89.