OPEN ACCESS

Assessment of Plantar Arch Index of Rivers State Indigenes in Rivers State University

Woroma Ibiwari Benwoke[1]*, Happy Uka-Nnodim, Odinakachi[1]

[1]Department of Anatomy, Faculty of Basic Medical Sciences, College of Medicine, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria

Abstract: In foot biomechanics, the medial longitudinal plantar arch plays a critical role. It is the most essential reference in determining the degree of flat foot since it serves as a footing and shock absorber while walking. It operates as an adaptable support basis for the entire body, dissipates weight-bearing forces, and stores energy throughout the gait cycle. Although arch complex dysfunction is typically asymptomatic, it can affect the biomechanics of the lower limbs and lumbar spine, increasing the risk of discomfort and injury. Consistent measurements can be used to ascertain foot types (such as flat feet and normal feet) based on their arches, as these describe the foot's plantar surface contact area. Staheli's Plantar Arch Index (SPAI) is used to analyze these arches where a ratio between the widths of the mid foot and the heel region of the foot is gotten; this is called the Plantar Arch Index (PAI). A descriptive cross-sectional design was used to recruit 427 Rivers State indigenes of the university. The students were clustered into 15 tribes in Rivers State and 29 students were randomly selected from each of the tribes. Foot impressions were retrieved via the ink and paper method. The plantar arch index was used to diagnose and analyze for flat foot. 211 males and 216 females were recruited for the study with a mean age of 24 years ±3. The prevalence of flat feet among the respondents was 12.6% where males accounted for 42.6% and females accounted for 57.4%. Females were recorded to have a higher prevalence. It was also observed that among the respondents, there was an 11.1% and 88.9% prevalence of unilateral and bilateral flat feet respectively. This study among Rivers State indigenes in Rivers State University disclosed a prevalence rate that is comparable to other adult population. Females exhibited a greater risk of this disorder, so should be given special attention. It is recommended that proactive efforts be made in the areas of screening, prevention, and monitoring of flat feet.
Keywords: Plantar Arch, Plantar Arch Index, Flat foot, Rivers State Indigenes.

INTRODUCTION

Flat feet are common foot deformity in which the medial longitudinal arch of the foot is distorted, causing the medial longitudinal arch of the foot to come closer to the ground or make touch with the ground (Raj and Tafti 2010). A flat foot is one in which the entire sole of the foot is in contact or near contact with the ground while standing (Radovic 2016). The incidence of flat feet can either be unilateral (one foot) or bilateral (two feet). Flat feet have been identified as the most common foot pathology in patients of all ages, but especially in paediatric orthopaedic practice (Ibeabuchi *et al.,* 2014). Flat feet usually disappear by the age of six years as the feet become less flexible and the arches form, only roughly one or two out of every ten children will grow up with flat feet (Burns *et al.,* 2016); conversely, Badii (2019) reported that flat feet disappear at ages two or three years. Flat foot usually causes tissue sprain, pain, impaired function, and disability in lower extremities which has a negative impact on the quality of life (Abich *et al.,* 2020).

Fernandez *et al.,* (2017) reported the prevalence of flat feet among adults 40 years and above to be 26.62%. Similarly, Ibrahim *et al.,* (2019) described a prevalence of 42.24% among school children in Karachi aged 11-16 years in which 23.3% had unilateral

*Corresponding Author: Woroma Ibiwari Benwoke
Depart ment of Anatomy, Faculty of Basic Medical Sciences, College of Medicine, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria

flat feet and 19% had bilateral flat feet. Also, Ibeabuchi *et al.,* (2020) observed a prevalence of 13.53% in a 15-year-old Nigerian school children population in Lagos State.

Measurements such as the Plantar Arch Index can be used to determine foot types based on their arches, as these describe the plantar surface contact area and consequently aid in detection of flat feet (Okezue *et al.,* 2019).

The Arch Index (AI) was created by Cavanagh and Rogers in 1987, and it indicates the ratio of the area of the middle third of a footprint to the overall area excluding the toes, with a larger ratio indicating a flatter foot. The AI has been shown to have excellent reliability, is highly correlated with navicular height and angular measures determined from radiographs, is sensitive to age-related differences in foot posture, and is correlated with pressures under the mid foot and rear foot motion when walking (Pita-Fernandez *et al.,* 2017). In an assessment on plantar arch index, Hernandez *et al.,* (2007) reported that Engel and Staheli propose that the relationship between arch region width and heel region width recorded on a footprint be used to measure plantar arch growth.

There are however several studies concerning flat feet prevalence but there is paucity of information on flat feet prevalence among Rivers State indigenes in Rivers State University, hence the need for this study

MATERIALS AND METHODS

Study Area
The study was carried out in Rivers State University. It is a state university located in Nkpolu Oroworukwo village, Mile 3 Diobu in Obio-Akpor Local Government Area of Rivers State

Study Design
A descriptive cross-sectional design was employed for the study.

Population of the Study
The population of the study consists of registered undergraduates Rivers State indigenes in the University.

Inclusion Criteria
1. Undergraduates of the university.
2. 18-30 years of age.
3. Undergraduates whose both parents are from Rivers State.

Exclusion Criteria
1. Students with past record of foot surgery and/or injury.
2. Students with congenital malformations of the feet.
3. Students outside the main university campus.

Sample Size Determination
The formula employed was $N = \frac{Z^2 \, X \, P \, X \, q}{d^2}$

Where:
N= Sample size
P = Proportion from previous study (0.5) (Ibrahim *et al.,* 2019)
q = (1-P) = 1- 0.5 = 0.5
d= Degree of accuracy (0.05)
Z= Level of significance (at 95% = 1.96)

Hence, N= $(1.96)^2 \times (0.5) \times (1- 0.5)/(0.05)^2$
$= 3.8416 \times 0.5 \times 0.5/0.0025$
$= 384$

Calculating for 10% adjustment:
N/1-10%
N = Sample size
= 384/1-0.1
= 384/0.9
= 427
Therefore 427 respondents were used for this study.

Sampling Technique
A cluster sampling technique was employed for this study. The respondents were clustered into 15 tribes in Rivers State namely; Ijaw, Etche, Engenni, Eleme, Nkoroo, Ogoni, Nkoro, Opobo, Ekpeye, Degema, Ogba, Abua, Ibani, Ikwerre and Kula. 29 respondents were selected per tribe by simple random sampling (balloting).

Instruments for the Study
The instruments for the study were stamp pad, ink and A4 paper for obtaining and recording plantar impressions of the feet and a semi structured self-administered questionnaire for obtaining socio-demographic characteristics.

Study Procedure
Participation in the study was voluntary. Informed consent was obtained from participants. The respondents were met at their cultural union meetings and socio-demographics of each respondent such as sex, age, name of school, Local Government Area and tribe were obtained. For obtaining foot impressions, ink was poured on a pad and distributed evenly using a roller. The respondents were asked to clean their feet, after which they were requested to place both soles on the pad to ensure proper distribution of weight between the two feet, then the inked feet were carefully transferred onto a plain white A4 size paper kept aside on a flat surface. The feet of the participants were washed with soap and water and cleaned immediately. The impression of both feet were taken and Staheli's PlantarArch Index (SPAI) was used for the analysis. On the impression, a tangential line was drawn on the medial side of the metatarsal and heel region. A perpendicular line was then drawn from the midpoint of the tangential line to cross the footprint. The width that was covered with ink from the medial side

to the lateral side was measured and was called A value or the Mid Arch Width (MAW).

Another perpendicular line was drawn at the heel region from the tangential line and the width that was covered with ink from the medial side to the lateral side was also measured and was called the B value or the Width at Heel (WAH).

Staheli's Plantar Arch Index (SPAI); A ratio between the widths was calculated by dividing the value of A by the value of B, that is (SPAI = A/B). A student was considered to be flatfooted if he or she had an Arch Index ≥1.15.

Ethical Clearance
the study was approved by the Department of Human Anatomy, College of Medical Sciences, Rivers State University. Written informed consent was obtained from participants.

Statistical Analysis
The data was analyzed using SPSS (version 25.0. Continuous variables were expressed in mean (SD). The study adopted descriptive statistical methods of measures of central tendency such as arithmetic mean, mean, standard error and percentage frequency. Inferential statistics of paired t-test were used for determining statistical differences. Confidence level was set at 95% with significance of the difference accepted at $p \leq 0.05$.

RESULTS
Validity of Results
The 427 respondents that were involved in this study were all useful for the study and for the analysis, hence there was a 100% respond rate.

Table 1: Socio-Demographics of Respondents

Variable	Frequency n=427	Percentage (%)
Sex		
Male	211	49.4
Female	216	50.6
Total	427	
Age (in years)		
18-25	250	58.5
25-30	177	41.5
Mean Age	24±3	
Tribes	29	6.8
Ijaw	29	6.8
Etche	29	6.8
Engenni	29	6.8
Eleme	29	6.8
Nkoroo	29	6.8
Ogoni	29	6.8
Nkoro	29	6.8
Opobo	29	6.8
Ekpeye	29	6.8
Degema	29	6.8
Ogba	29	6.8
Abua	29	6.8
Ibani	29	6.8
Ikwerre	29	6.8
Kula	29	6.8

Table 2: Prevalence of Flat feet among respondents

Foot Findings	Frequency (n=427)	Percentage (%)
Normal Feet (SPI ≤1.15)	373	87.4
Flat Feet (SPI ≥1.15)	54	12.6
Total	427	

Table 2 showing out of 427 participants, 54 (12.6%) had flat feet. The remaining 373 (87.4%) had normal feet.

Table 3: Prevalence in Males and Females

Sex	Frequency (n=54)	Percentage (%)
Males	23	42.6
Females	31	57.4

Table 3 showing out of the 54 participants with flat feet, 23 were males and 31 were females. Males had a lesser prevalence of 42.6% while females had a higher prevalence of 57.4%.

Table 4: Prevalence of Flat Feet Pattern

Feet Pattern	Frequency (n=54)	Percentage (%)
Unilateral	6	11.1
Bilateral	48	88.9

Table 4 shows 6 persons were reported to have unilateral flat feet and 48 persons, bilateral flat feet. Unilateral flat feet showed a prevalence of 11.1% while bilateral flat feet were 88.9% prevalent.

DISCUSSION

Prevalence of Flat feet

The number of participants diagnosed with flat feet was 54, yielding an overall prevalence of 12.6%. This is similar with the study carried out by Eluwa *et al.,* (2009) on Akwa-Ibom students in the University of Calabar in which the total prevalence was 13.4%. Similar prevalence values of 13.53% was reported in a study by Ibeabuchi *et al.,* (2020) and that of Ukoha *et al.,* (2012) which was 13.9%. However, the prevalence for the present study is significantly lower than the prevalence values of 25.3% and 25% reported by Dare *et al.,* (2012) and Umar and Adeyemi (2010), respectively.

Elsewhere in Africa, studies on Ethiopian children and Ghanaian tribes showed fairly higher prevalence of 17.6% and 15.1% respectively (Abich *et al.,*2020; Adjei-Antwi *et al.,*2020) while Igbigbi and Mpango (1998) reported a lesser prevalence value of 9.88% in Ugandan University Students.

The prevalence recorded in this study is comparatively lesser compared to a study conducted by Reihaneh *et al.,* (2013) and Pfeiffer *et al.,* (2006) where the prevalence of flat feet were 74% and 44% in a group of 7–12-year-old children. The differences in these values may be due to the age limit set in these studies. The upper and lower limit set for the present study was from 18 years and 30 years whereas in these studies, it was from 3 years and above, in which the lower age limit of 3 years serves to be a major contributor of high percentage in flat foot.

Sex Distribution of Flat feet

Among the participants with flat feet in the present study, 23 of them were males while 31 were females. The prevalence of flat feet in this study was seen to be 42.6% in males and 57.4% in females. It is therefore seen that the prevalence of flat feet was commoner in the females. This higher prevalence in females corresponds to the results reported by Eluwa *et al.,* (2012) where the prevalence values in males and females were 5.8% and 7.6% respectively. It is also in line with a study carried out by Ukoha *et al.,* (2012) where males had a total prevalence of 6.8% and females had a total of 7.1% prevalence. This higher prevalence in females may be due to the fact that females tend to have small bones and less bulky muscles, since both factors help in the maintenance of the arches of the foot, females are therefore, more prone to developing flat feet (Hicks 1995). Reihaneh *et al.,* (2013) reported that it could also be as a result of greater laxity of the female joints and ligaments. "The laxity in the posterior and anterior cruciate ligaments of the foot increases in women due to the increase in oestrogen just before ovulation" Petrofsky and Lee (2016) reported. Hannan (2013) further stated that the female pelvic bones are wider and the hips are swayed upon movement hence the likely cause of being more affected with flat feet. However, in some other studies like Ibeabuchi *et al.,* (2020), males accounted for a higher prevalence of 66.1% than females which was 33.9%. A higher prevalence was also observed in males in an investigation by (Umar and Adeyemi, 2010) where overall incidence in males was 13% and 12% in females.

Furthermore, this result tallies with the reported prevalence in Ugandan students were males had a lesser prevalence value of 3.11% than females which was 6.67% (Igbigbi and Mpango 1998); but in Ghana, Adjei-Antwi *et al.,* (2020) reported a higher prevalence in males which was 15.7% and 14.1% in females.

In Iran, Reihaneh *et al.,* (2013) recorded a higher prevalence in females which was 75.2% while males accounted for 72.6% prevalence. Samarakoon *et al.,* (2020) also gave report on a higher prevalence value of the females which was 53.9% while in males was 48.9%. Conversely, males accounted for a higher prevalence in a study done by Pfeiffer *et al.,* (2006) in Spain where the individual prevalence values recorded for males and females were 52% and 36% respectively.

Pattern of Flat Feet

Following this study, it was observed that among participants with flat feet, 11.1% had unilateral flat feet while 88.9% had bilateral flat feet, hence bilateral flat feet was seen to be commoner among the participants. This prevalent pattern is in accordance with a study on athletes in Port-Harcourt carried out by Didia and Asomugha (2004) where bilateral flat feet was prevalent, yielding a total incidence of 7.5% while unilateral flat feet incidence was 3.5%. There was also a higher prevalence of bilateral flat feet in subjects in a study carried out by Ezema *et al.,* (2014) where 91.5% of the population came down with bilateral flat feet and only 8.5% had unilateral flat feet.

This study is also similar to a study done in Pakistan by Ibrahim *et al.,* (2019) where the prevalence of bilateral flat feet was 23.3% prevalent while unilateral flat feet was 19% prevalent and also an investigation by Reddy and Kishve (2021) where it was observed that bilateral and unilateral flat feet were 11.6% and 3% prevalent respectively. However, Samarakoon *et al.,* (2020) recorded a higher prevalence in unilateral flat feet where 64.4% of the subjects with flat feet had unilateral flat feet and 35.6% had bilateral flat feet.

CONCLUSION

This study was conducted to determine prevalence of flat feet in Rivers state indigenes of Rivers State University using measurements of mid arch width and width at the heel region from feet impressions obtained via ink and paper method. The total prevalence of flat feet was 12.6% in a sample of 427 measured feet. The study also showed that females had a higher prevalence rate than males. Bilateral flat feet were prevalent among the participants than unilateral flat feet.

RECOMMENDATIONS

1. It is recommended that proactive efforts be made in the areas of screening, prevention, and monitoring of flat feet.
2. Further studies should be carried out on the prevalence of flat feet in Rivers State to compare with other tribes and regions of the world.

REFERENCES

- Abich, Y., Mihiret, T., Yihunie, A. T., Gashaw, M., & Janakiraman, B. (2020). Flatfoot and associated factors among Ethiopian school children aged 11–15 years: A school-based study. *PLOS ONE*, *15*(9), e0238001. https://doi.org/10.1371/journal.pone.0238001
- Adjei-Antwi, C., Abaidoo, C. S., James, N., & Joshua, T. (2020). Morphometric study of plantar arch index and the prevalence of flat foot among tribes in Ghana. *International Journal of Anatomy and Research*, *8*(1.1), 7241–7246. https://doi.org/10.16965/ijar.2019.349
- Badii, M. (2019). Anatomical variations of the foot arches and their clinical significance. *Journal of Foot and Ankle Research*, *12*(1), 45–52.
- Burns, J., Crosbie, J., Hunt, A., & Ouvrier, R. (2016). The effect of pes cavus on foot pain and function. *Foot & Ankle International*, *26*(9), 701–708.
- Dare, N. W., Onyije, F. M., & Osoma, S. (2012). Pes planus (flat foot) in male and female adults of Bayelsa State, Nigeria. *Electronic Journal of Biomedicine*, *2*, 25–30.
- Didia, B. C., & Asomugha, A. L. (2004). The incidence of flatfoot amongst athletes in Port Harcourt. *Journal of Experimental and Clinical Anatomy*, *3*(2), 58–59.
- Eluwa, M. A., Omini, R. B., Akpantah, A. O., & Ekanem, T. B. (2009). The incidence of pes planus amongst Akwa-Ibom State students in the University of Calabar. *The Internet Journal of Forensic Science*, *3*(2).
- Eluwa, M. A., Omini, R. B., Akpantah, A. O., & Ekanem, T. B. (2012). The incidence of pes planus amongst Akwa-Ibom State students in the University of Calabar. *The Internet Journal of Forensic Science*, *3*(2).
- Ezema, C. I., Abaraogu, U. O., & Okafor, G. O. (2014). Flat foot and associated factors among primary school children: A cross-sectional study. *Hong Kong Physiotherapy Journal*, *32*(1), 11–20. https://doi.org/10.1016/j.hkpj.2013.05.001
- Hannan, M. T., Menz, H. B., Hillier, S., & Taylor, A. W. (2013). Foot posture and function: Relationship with age and musculoskeletal pain. *Gait & Posture*, *37*(4), 530–535.
- Hernandez, A. J., Kimura, L. K., Laraya, M. H. F., & Favaro, E. (2007). Calculation of Staheli's plantar arch index and prevalence of flat feet: A study with 100 children aged 5-9 years. *Acta Ortopédica Brasileira*, *15*(2), 68–71.
- Hicks, J. H. (1954). The mechanics of the foot: II. The plantar aponeurosis and the arch. *Journal of Anatomy*, *88*(Pt 1), 25–30.
- Ibeabuchi, N. M., Olabiyi, O. O., Uduku, L. O., & Osinubi, A. A. (2014). Plantar arch index and its relationship with body mass index in a young adult Nigerian population. *Journal of Experimental and Clinical Anatomy*, *13*(2), 48–52.
- Ibeabuchi, M., Obun, C., Olabiyi, O., Oluwabusola, E., & Adebayo, A. (2020). Prevalence of flat foot among 6-15 year old Nigerian school children residents in Lagos. *Journal of Anatomical Sciences*, *11*(1), 61–67.
- Ibrahim, S., Khan, M. S., Asif, M., & Hussain, F. (2019). Prevalence of flat feet among school children. *Indian Journal of Physiotherapy and Occupational Therapy*, *13*(3), 136–140.
- Igbigbi, P. S., & Mpango, L. (1998). Prevalence of pes planus amongst the students in Mbarara University of Science and Technology, Uganda. *Annals of Tropical Medicine and Parasitology*, *92*(3), 327–331.
- Okezue, O. C., Akamadu, N. C., & Onuoha, C. A. (2019). Relationship between plantar arch index and selected physical characteristics of school children in Enugu, Nigeria. *Bulletin of Faculty of Physical Therapy*, *24*(1), 1–7.
- Petrofsky, J. S., & Lee, S. (2016). The effect of flat foot on the balance and muscle activity during walking in young and older adults. *Journal of Medical Science and Clinical Research*, *4*(2), 9182–9192.
- Pfeiffer, M., Kotz, R., Ledl, T., Hauser, G., & Sluga, M. (2006). Prevalence of flat foot in preschool-aged

children. *Pediatrics*, *118*(2), 634–639. https://doi.org/10.1542/peds.2005-2126

- Pita-Fernandez, S., Gonzalez-Martin, C., Alonso-Tajes, F., Seoane-Pillado, T., Pertega-Diaz, S., Perez-Garcia, S., Seijo-Bestilleiro, R., & Balboa-Barreiro, V. (2017). Flat foot in a random population and its impact on quality of life and functionality. *Journal of Clinical and Diagnostic Research*, *11*(4), LC22–LC27. https://doi.org/10.7860/JCDR/2017/24362.9697
- Radovic, P. (2016). Clinical evaluation of the longitudinal arch of the foot using the footprint method. *International Journal of Orthopaedics*, *3*(5), 621–626.
- Raj, M. A., & Tafti, D. (2023). *Anatomy, bony pelvis and lower limb, foot arches*. StatPearls Publishing.
- Reddy, S. K., & Kishore, K. (2021). Assessment of plantar arch index in adults and its correlation with gender and BMI. *International Journal of Health Sciences and Research*, *11*(3), 85–91.
- Reihaneh, A., Aliabadi, F., & Ghorbani, A. (2013). Prevalence of flat foot: Comparison between male and female primary school students. *Iranian Rehabilitation Journal*, *11*(18), 22–24.
- Samarakoon, J., Lakshitha de Silva, N., & Fernando, D. (2020). Prevalence and associated factors of flat feet among patients with hypertension. *Archives of Clinical and Biomedical Research*, *4*(5), 450–463.
- Ukoha, U., Egwu, A. O., Okafor, J. I., Ogugua, P. C., Igwenagu, V. N., & Udemezue, O. O. (2012). Incidence of flat foot among an adult population in Anambra State, Southeast Nigeria. *International Journal of Biological and Medical Research*, *3*(3), 1937–1940.