Prevalence of Flat Foot among School-Aged Children in a Nigerian Population

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ABSTRACT

Background: A flatfoot deformity is a common foot deformity in children worldwide, with wide and varied prevalence estimates. This may predispose to a rigid deformity that may result in chronic foot pain, back, hip and knee pain requiring avoidable complex surgical procedures. **Objectives:** To determine the prevalence of flatfoot deformity in the study population using the method of footprint, and its relationship with age, sex, and body-mass index (BMI). **Materials and Methods:** The static footprints of 1758 primary school children, aged 5 to 13 years, were obtained using the ink method on a white duplicating paper from 8 randomly selected primary schools within the study area. Subjects included age-class matched 5 to 7 years who were in classes 1 and 2, 8 to 10 years who were in classes 3 and 4, and 11 to 13 years who were in classes 5 and 6. Weight and height were measured, and the BMI was calculated. The footprint was measured to classify the foot into normal and flatfoot. Data was analyzed using SPSS version 21. **Results:** The prevalence of flatfoot deformity was 15.69% in this study with a male: female ratio of 1: 1.1. The prevalence of flatfoot deformity decreased with increasing age, which was significant at p=0.000. There was no significant association between flatfoot deformity and BMI, (p=0.820). **Conclusion:** Flat foot is a common foot deformity in the study population. Its prevalence decreases with age, and it occurs equally in both gender. BMI did not affect flatfoot.

Keywords: Children; deformity; flatfoot deformity; footprint; prevalence.

INTRODUCTION

A normal foot is required for appropriate posture and locomotion.[1, 2] What constitutes a normal foot may be wide and varied depending on the population being considered.[3] However a normal foot must be plantigrade, flexible, and pain-free, and free from any obtrusive deformity.[4] The foot arch provides a springy support for shock absorption during stance and locomotion.[5] There are three orthopaedic foot arches: the medial, the lateral and the transverse arches.[6] The
medial arch is made up of the calcaneus, talus, navicular, cuneiforms, the medial metatarsals, and their accompanying ligamentous and other soft tissue attachments. The lateral arch is formed by the calcaneus, cuboids, lateral metatarsals, and their ligaments. The transverse arch is a hemi- arch that gets only completed when the two feet are put together.[7] The foot arch needs to be in

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optimum condition for the foot to perform its functions satisfactorily.[8]

The foot may be normal or abnormal (flat or high arched). Arch abnormalities especially flatfoot constitute a common pediatric foot deformity across the globe for which orthopedic clinics are visited worldwide.[9, 10] A flatfoot occurs when the medial arch is unsupported due to bony

Abnormality or ligamentous laxity such that the medial aspect of the sole of the foot touches the ground on stance. This may be usual in early childhood, common in late childhood, and frequent in later lives.[11, 12] This may represent the evolution in the stages of arch development as the child grows. The arch is thought to have been fully developed by age ten years.[13, 14]

The diagnosis of a flatfoot could be made clinically with the use of footprint indices like Staheli arch index, Chippaux-Smirak index, Clark's angle, instep width method, or using radiographic measures. [15-17] Footprint analysis has become a common tool in the diagnosis of flatfoot because of its simplicity and cost-effectiveness especially when utilized in a field study. [14,15] However, there have been several methods by which flat foot may be diagnosed using footprint parameters, resulting in wide and varied prevalence estimates. [14, 15, 18-22]

Flat foot deformity when it is not corrected early may result in a painful rigid deformity that may require complex surgical procedures such as corrective osteotomies and arthrodesis with attendant costs and complications, as well as poorer outcomes compared to when intervention is early. Biomechanics of the child's walking may be adversely affected as the stiff foot loses the kinematic coupling that is needed for normal motion especially on rough surfaces. Also, flatfoot deformity when not corrected early may result in painful knee, hip, or spine which may become chronic and may persist even after later intervention. The knowledge of the prevalence Pattern and its variation with age, sex, and body-mass index (BMI) will aid in the early detection and treatment of flatfoot thereby avoiding the problems enumerated above. This will also supply useful data from our environment to compare with that of researchers from other climes.

This study was therefore to determine the prevalence of flatfoot using the instep method of Footprint analysis in a Nigerian population.[22] It also sought to determine the relationship between flatfoot and age, sex, and body-mass index.

MATERIALS AND METHODS

This was a cross-sectional descriptive study involving one thousand seven hundred and fifty-eight pupils who were randomly selected from eight primary schools within Benin City, Edo State, in Southern Nigeria. Subjects were drawn from three local governments that make up Benin City; Oredo, Egor, and Ikpoba Okha local governments. There were 649 primary schools (165 public and 484 private) within Benin City at the time of study.

The study was carried out between September 2015 and November 2016. Children in the study environment commonly start primary school at age 5 and exit at age 12, hence the inclusion of ages 5 to 13 years in the study. Only subjects who were of Nigerian descent and attended school in Benin City were included.

We estimated the sample size for this study using the formula: $N = Z^2 pq / d^2$ where; N=estimated sample size where population is greater than 10,000; Z=the standard normal deviate, 1.96 at 95% confidence level; P=proportion of target population, 50% (0.5); q=1-p, ie 1-0.5=0.5; d=the degree of precision required, 0.02; $N= 1.96^2 \times 0.5 \times 0.5 / 0.02^2$ $=0.9604 \div 0.0004 = 2401$

A simple random sampling was used to select eight primary schools within the study area, seven of which were public schools while 1 was a private school. The schools were randomly selected from a list containing all the schools within the three local governments in the study area. Two public schools each were selected from each of Egor and Ikpoba Okha, and three public schools from Oredo were selected for the study. The only private school was randomly selected from Oredo. Pupils were divided into three groups using the age-class match; group one were pupils aged 5 to 7 years and were in class 1 and 2, group two were aged 8 to 10 years and were in class 3 and 4, while group three were aged 11 to 13 years and were in class 5 and

6. All those who met the age-class match and who were present for each day of the study were included. This was done for the pupils in each school sampled to select 251, 255, 238, 174,116, 257, 231, and 236 subjects from the respective schools to make up the 1758 subjects we recruited for the study. We included only children who met the age-class match whose parents and headteachers gave consent and who could maintain erect posture and follow instructions duly. Children who were from other races, those who had injuries, swellings or deformities in any part of the lower limbs, and those that could not stand erect were all excluded from the study.

Ethical Clearance was obtained from the ethical committee of the University of Benin Teaching Hospital with clearance certificate Number ADM/E22/A/VOL. VII/1193 approved 8th April 2015. Approval was also obtained from the Ministry of basic education, Edo State government with protocol number MBE/A/144 before we commenced the study. Informed consent was also obtained from the head teacher of each of the schools that we sampled as well as from the Parents through the leadership of the Parent Teachers Association of each school we sampled.

Author CCN worked with two health assistants who were previously trained to collect data for the study. The same assistants were used throughout the study period to reduce inter-observer bias.

Each child was quickly examined checking for any obvious foot deformity, injuries, swellings or the presence of any condition of the lower limb that will preclude the child from being able to maintain erect posture all of which will exclude the child from the study.

Each child was made to remove his/her shoes/sandals and stand on a standard bathroom scale (the Big Boss) which measures to 0.1kg which was standardized each day of the study using a known 1kg weight to obtain the weight of each child in kilograms. The height of each child in centimeters was obtained by having the child stand erect against a wall on which we previously marked a scale with ink using a measuring tape making sure each child stands with the heel, buttock, and occiput touching the wall with the child looking straight. The height is then marked off at the vertex with a horizontally placed rigid ruler.

Each child's static footprints (right and left) were then obtained by making the child stand on a board containing an inked pad placed horizontally on the floor, and then step on a white duplicating paper neatly placed on a flat surface in front of the ink board assisted to ensure the foot stepped on the duplicating paper in a neutral position, and then steps off to the ground. The footprints thus obtained were taken home and analyzed at convenience.

The footprint grading was done by having a tangent drawn through the medial edge of the foot print. A bisector was then drawn perpendicular to this tangent at the midfoot, and the points of intersection of this bisector with the tangent, medial and lateral edges of the footprint labeled A, B and C respectively. Line AB representing the width of the instep was measured in centimeters using a spreading caliper, while line BC representing the narrowest part of the midfoot was also measured in centimeters using the same spreading caliper, (See figure 1). If line AB was > or =1 cm, the footprint was regarded as a normal one, but if line AB was <1 cm it was regarded as a flat foot, (see figure 2). [23]

Data Analysis

The height obtained in centimeters was then converted to meters and then used in calculating the BMI for each child using the formula BMI=weight (kg)/Height^2 (meter). The BMI was classified into Underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), and obese (30 and above). [24]

Subjects were divided into three groups based on their ages, (5-7, 8-10, 11-13) years, and each group was then subgrouped into male and female. All data: biodata, weight, height, BMI, footprint grade classified using the width of the instep into the flat (AB<1 cm) or normal foot (AB> or =1 cm) were entered into Microsoft Excel and sorted and analyzed using SPSS version 21.

Descriptive statistics were obtained and mean values were compared using the student's t-test. Relationships were assessed using the chi-square tests of independence for parametric and non-parametric data. All p-values less than 0.05 were accepted as significant.

RESULTS

One thousand seven hundred and fifty-eight (1758) participants aged 5 to 13 years were studied which gave a total of 3516 feet. Eight hundred and fourteen (46.3%) subjects were males while 944 (53.7%) were females. Of these 566 (32.2%) were 5 to 7 years, 625 (35.6%) were aged 8 to 10 years, and 567 (32.3%) were aged 11 to 13 years. The mean age of the population was 9.18 ± 2.170 years, while the mean BMI was 15.09 ± 2.145 kg/m^2. 1641 (93.3%) were underweight, 114 (6.4%) were of normal BMI, 1 (0.1%) was overweight, and 2 (0.2%) were obese (see table 1).

The overall prevalence of flatfoot found in this study was 276/1758; 15.69% (see figure 3).

More females 143 (51.8%) than males 133 (48.2%), (a male:female ratio of 1:1.1) had flat feet but this was not significant, (p=0.529). More so, the sex-specific prevalence was 133/814; 16.3% for males, and 143/944; 15.2% for females.

Flat foot decreased significantly with age: from 126 (45.7%) among the 5 to 7-year group, through 100 (36.2%) among the 8 to 10-year group, to 50 (18.1%) among the 11 to 13-year age group. This was significant at p<0.001.

Flatfoot was found in the majority of those who were underweight 258 (93.5%), and those with normal BMI 18 (6.5%) but there was no significant relationship between flatfoot and BMI, (p=0.818) (see table 2).

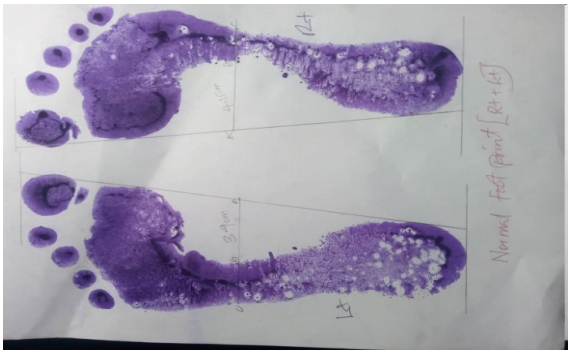

Figure 1: The footprints of a child with normal feet, AB>1 cm.

Figure 2:The footprints of a child with flat feet, AB<1cm

Table 1: Distribution of the subjects according to Sex, Age, and BMI.

Variables	Frequency (n=1758)	Percentage (%)
Sex		
Male	814	46.3
Female	944	53.7
Total	1758	100
Age (years)		
5-7	566	32.0
8-10	625	36.0
11-13	567	32.0
Total	1758	100
BMI (kg/m^2)		
Underweight (<18.5)	1641	93.3
Normal weight (18.5-24.9)	114	6.4
Overweight (25-29.9)	1	0.1
Obese (>30)	2	0.2
Total	1758	100

Mean age=9.18 ± 2.17, mean BMI=15.09 ± 2.145

Table 2: Relationship between flatfoot and Sex, Age, and BMI.

Variable	Flatfoot (276)	X^2/p value
Sex		0.396/0.529
Male	133 (48.2)	
Female	143 (51.8)	
Total	276 (100)	
Age (years)		38.747/0.000
5-7	126 (45.7)	
8-10	100 (36.2)	
11-13	50 (18.1)	
Total	276 (100)	
BMI (kg/m^2)		0.824/0.820
Underweight (<18.5)	258 (93.5)	
Normal (18.5-24.9)	18 (6.5)	
Overweight (25-29.9)	0 (0)	
Obese (>30)	0 (0)	
Total	276 (100)	

Age is significantly associated with flatfoot; flatfoot decreases with increasing age, p=0.000

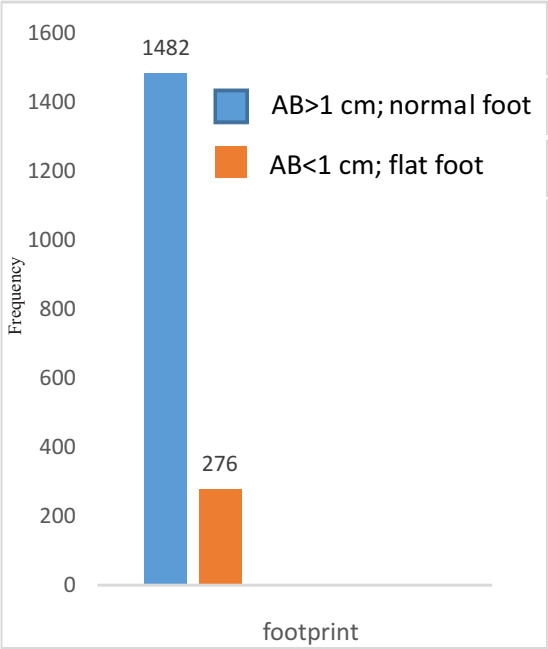

Figure 3: frequency of flatfoot within the study population.

DISCUSSION

Flatfoot was assessed in this study using the method of foot print analysis which has been found to be reliable and safe.[25]

This study found an overall prevalence of 15.69% which suggests that flat foot is a common paediatric foot deformity in this study population being present in about one out of every six children. This deformity is almost as common in males as it is in females (133/16.3%, 143/15.2%).

The prevalence estimates documented by previous studies are wide and varied. A systematic review carried out by Uden, et al.[26] reported the prevalence estimates to range between-0.6 to 77.9%. Our results are similar to the findings by Li et al. who reported a prevalence of 13.88%, as well as Tenebaum et al, who reported a prevalence of 12.4% in a predominantly adolescent population.[27,28] Also Ashok et al. reported a prevalence of 13.6% in an early adult Indian population, while Ibeabuchi et al. also reported a prevalence rate of 13.53% in a 6 to 15 year age group of school children in Lagos, Nigeria.[29, 30]. In contrast, Chang et al. evaluated 2083 Taiwanese Children aged 7 to 12 years and reported an overall prevalence of 59%, while Spahn et al. reported a prevalence rate of 6.2% of flexible flatfoot in an adolescent population. [31, 10] The reasons for these apparently wide differences are perhaps related to differences in age and BMI, as well as differences in racial characteristics of arch development, and differences in the methods used in obtaining the foot print. Also our findings contrasts with that reported by Umar et al. who documented a prevalence rate of 10% among a population of 9 to 14-year old-children in Northern Nigeria.[32]. This disparity may be due to the small sample size (200) used by Umar et al. as against 1758 in our study.

This study found no statistical significant difference between males 133 (48.2%) and females 143 (51.8%) with flatfoot. The sex specific prevalence was 16.3% for males and 15.2% for females. This is in contrast to the study by Tenebaum and colleagues who reported a male prevalence of 16.2%, and a female prevalence of 11.7% in an adolescent population.[28] This difference may be due to their higher sample size 825,964 (467412 males, and 358552 females) and the fact that their study involved adolescents. Also Umar and colleagues found a female preponderance of 13% against males 7%.[32] This may be due to differences in the ethnic characteristics of the study populations.

This study found that flatfoot decreased progressively as the age increased. It was most common among the 5 to 7-year age group 126 (45.7%) and least common among the 11 to 13-year age group 50 (18.1%). Age was significantly associated with flatfoot ($p<0.001$). Previous studies suggest that most children are born with flat feet due to the presence of the fat-pad and poorly developed medial longitudinal arch, and that most children would have fully developed the medial longitudinal arch by age 8 to 10 years explaining the trend of reduction of prevalence of flatfoot as the age increases as observed in this study.[33] This trend was also reported by Umar et al. and also by Abolarin and colleagues.[32, 34]

Flatfoot was found more in the underweight BMI category (93.4%), and normal BMI (6.6%), but no association was found with BMI. Flatfoot is thought to be associated with high BMI being found more in those who are overweight and those who are

obese.[35] This however is not our observation which may be due to the small group of overweight and obese subjects in our population (0.3%), in contrast to findings documented by other workers. [19, 36, 37, 38]

There is a need to carry out further study on similarly matched controls and high BMI in order to be able to make a categorical statement on the association between flatfoot and BMI. Similarly the reason for the very high percentage of low BMI in our study and the causes of under nutrition in our population needs to be investigated further.

Only about 0.3% of our study population were above the normal BMI. Our prevalence might have been different if we had a significant proportion of our study population with a BMI that is above the normal average value. Further evaluation using more of private schools as against public schools may provide higher proportion of high BMI group to enable its effect on the prevalence to be more accurately estimated.

CONCLUSION

Flatfoot was a common foot arch deformity among the children studied (15.69%) with no significant gender differences. Its prevalence significantly decreased with increasing age, and it was seen more in the underweight BMI. There was none seen among the overweight and obese BMI, and there was no significant association with BMI in the study. A screening program targeting the first decade with a view to identifying those involved early, and take measures to prevent complications may be justified.

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Author Contribution

Author 1 (CCN): substantially contributed to the conceptualization and design, literature review, data collection and analysis of this work. Drafted the manuscript substantially as well as contributed to its review. He also read and approved the final draft of the manuscript.

Author 2 (ESC): he contributed substantially to the concept and design, literature review as well as data collection. He also made substantial inputs in the review of the manuscript. He has read and approved the final draft of the work.

Author 3 (NCU): he contributed substantially to the literature review, drafting, reviewing and editing the manuscript. He read and approved the final draft.

Data Availability

The data used to support the findings of this study is available from the site publicly

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Conflict of Interest

None declared

Ethical Approval

This study was approved by the institutional ethics committee of the University of Benin Teaching Hospital with clearance certificate Number of ADM/E22/A/VOL. VII/1193 with approval date of 8th April 2015.

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