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Prevalence of Flat Foot among 6-15 Year Old Nigerian School Children Resident in Lagos

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ABSTRACT
Flatfoot or pes planus is defined subjectively as a weight-bearing foot with an abnormally low or absent longitudinal arch. It has been observed to be the most common foot pathology not only in patients of all ages in general but in pediatric, orthopedic practice in particular. The medial longitudinal plantar arch has crucial functions in foot biomechanics. It acts as a foothold and shock absorber during walking and is the most important reference in determining the degree of pes planus and pes cavus. The aim of the study was to determine the incidence of flat foot in children and to check if prevalence was sexually dimorphic. This cross sectional study was carried out on pupils and students of University of Lagos Staff Primary School and University of Lagos International Secondary School. A total of 218 volunteers comprising 117 females and 101 males with ages ranging from 6-15 years were recruited for the study. Obtained footprints were scanned using the Bearpaw™ scanner and saved in a personal computer. The scanned prints were exported to CorelDraw™ software, where measurements for Mid Arch Width and Width at the Heel were taken to calculate Staheli Index. Independent samples test was used to compare group means and unpaired T-test was used to check for sexual dimorphism. Data analyses was performed using SPSS version 16 software. The results show that the overall mean and standard deviation for Staheli Index of the subjects for both feet was 1.02±0.28. There was no significant difference between males and females. The overall percentage of subjects with flatfeet in the study was 59 (13.53%) out of a total number of 436 feet analyzed. Of these number, males accounted for 39 (66.1%) of flat feet while the number in females was 20 (33.9%). This prevalence estimates can serve as baseline data for podiatrist, shoe manufacturers and can be helpful in clinical practice.

Keywords: Flat feet, Medial Longitudinal Arch, Staheli Index, CorelDraw™.

INTRODUCTION
Traditionally, a flatfoot or pes planus has been defined subjectively as a weight-bearing foot with an abnormally low or absent longitudinal arch and has been observed to be the most common foot pathology not only in patients of all ages in general but in pediatric, orthopedic practice in particular. [1& 2]

Humans are born with flat feet especially of the flexible type, but as they begin to walk, they start developing normal arches throughout childhood. Research suggests that the optimal age range for arch development is 4 years and that arches are usually formed completely at around 8 years.[1]

The medial longitudinal plantar arch (MLA) has crucial functions in foot biomechanics. It acts as a foothold and shock absorber during walking. An increase or reduction of MLA can interfere with these functions and can lead towards muscular imbalance, articular misalignment, compensatory pronation of the foot, and gait abnormalities [3]. The medial longitudinal arch is also very important in maintaining the foot posture and is the most important reference in determining the degree of pes planus and pes cavus [4]. It is due to these salient reasons that calculation of medial longitudinal arch height has widely been used to categorize the foot into high arch, normal or a low arch foot [5]. It is well recognized that there is a higher incidence of flatfeet in blacks than Caucasians, and that most of these flat feet occurring in children are asymptomatic [6 & 7].

Numerous studies on the characterization of the foot using footprints from populations other than ours abound in literature [8, 9 & 10]. Bulk of the research data on flat foot that has been carried out previously in Nigeria by Didia *et al*[11] and Eluwa *et al* [12] mainly focused on the adult population, hence the need to generate data for a much younger population that are more susceptible to foot abnormalities.

Unnecessary treatment of asymptomatic pediatric flat foot can be expensive, with no evidence of change in the patient's outcome and there is little data to conclusively prove that flexible flatfoot in infants and children leads to long-term morbidity in adults. The lack of agreement on the need to treat flexible flat foot has resulted in the development of polarized, dogmatic and opposite philosophies regarding treatment [13 & 14].

Such dilemma is not only restricted to clinicians but also encountered by sport coaches who are tasked with training relatively young upcoming athletes, military and paramilitary organizations that recruit young people and shoe manufacturers who have to deal with the unpredictability in child growth patterns and the constantly changing foot.

As a result of paucity in consensus, "the experienced clinician's discretion" currently guides the decision on whether intervention into pediatric flat foot is required. It is therefore understandable that the decision "to treat or not to treat remains controversial [14].

The "controversial physicians' decision" is heavily reliant on anthropometric footprint data that is derived from studies such as ours.
The aim of this research is to determine the incidence of flat foot in children and evaluate the relationship between flat foot and gender.

MATERIALS AND METHODS

The study was carried out on pupils and students of the University of Lagos Staff Primary School and University of Lagos International Secondary School. This cross sectional study was carried out on 200 children. The cohort comprised of 117 females and 101 males with ages ranging from 6-15 years. The sample size was derived from 10% of the registered student's population.

Ethical approval was obtained from University of Lagos Health Research Ethics Committee (HREC) with a CMULHREC NUMBER; CMUL/HREC/11/17/314. The consent form approved by the University of Lagos Health Research Ethics Committee (HREC) was prepared in duplicate for reference purposes by both researcher and participants. Thus all experiments were performed in line with appropriate ethical considerations and in accordance with the standards laid down in the 1964 Declaration of Helsinki.
Subjects who had any previous history of foot surgery, tendoachilles, ligamentous laxity, and any other foot deformity were excluded from the study. We also excluded any of the child participants who could not stand erect long enough on the inked platform for their static footprint to be acquired. Measurements that had a high incidence of ink dispersal on the paper and/or that was unable to properly show the full outline of the foot were invalidated and retaken.

Methodology: Protocols for direct measurements of stature and weight were adopted from those established by the International Society for the Advancement of Kinanthropometry (ISAK).
Computer based measurements of scanned footprints for foot length, foot width and other anthropometric foot parameters was carried out using the CorelDraw™ (X7) application which was installed in a Microsoft windows8™ operating system. To the best of our knowledge, our study will be the first making use of the CorelDraw™ application used to carry out these measurements. Previous studies employing these computer-based protocols have used other similar applications like F-scan measuring system and software by Tekscan Inc™, South Boston, Massachusetts [2]. Menz and Munteanu [15] also measured footprints using a computer graphics tablet (Wacom Technology Corporation, Vancouver, Canada) and graphics software (Canvas™ 8.0; ACD Systems, Miami).

Foot Print Measurements

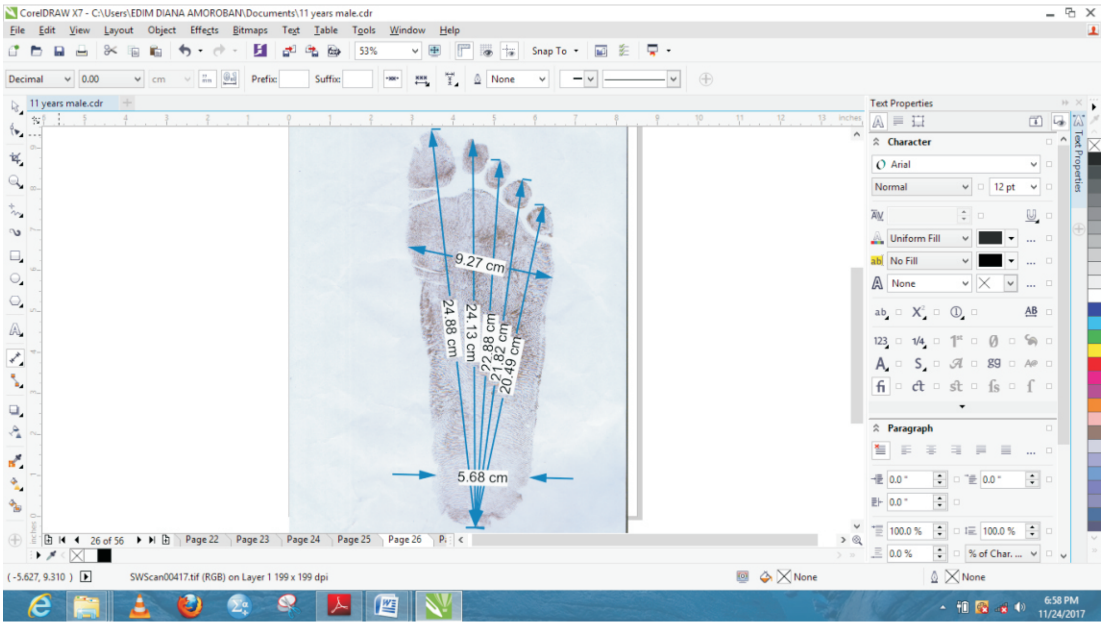

Figure 1: CorelDraw™ software interface used in this study.

To obtain a footprint, participants were properly briefed on what there were required to do after which we had the sole of their feet washed and cleaned. They were then asked to firmly place both feet on the already inked foot pads. We then guided the foot onto a white A4 paper, making sure all areas of the foot impression were left on the paper. We ensured that they stood "astride" in such a way that their body weight was equally distributed on both feet. Participants' feet were then washed and dried.

Obtained footprints were then scanned using the Bearpaw™ scanner and saved in a personal computer. The scanned prints were exported to CorelDraw™ software, where measurements for Width at Heel (WAH) and Mid Arch Width (MAW) were carried out. These measurements were then used to calculate the Staheli index.

For each foot, Staheli Index was calculated by dividing the Mid Arch Width (MAW) over the foot Width at Heel (WAH) as described by [16].

This was to determine the presence of pes planus. The arch indices can range from 0.0-1.0 and are indicative of cavus and planus foot respectively though, the normal range of Plantar Arch Index is between 0.5-0.8. [17].

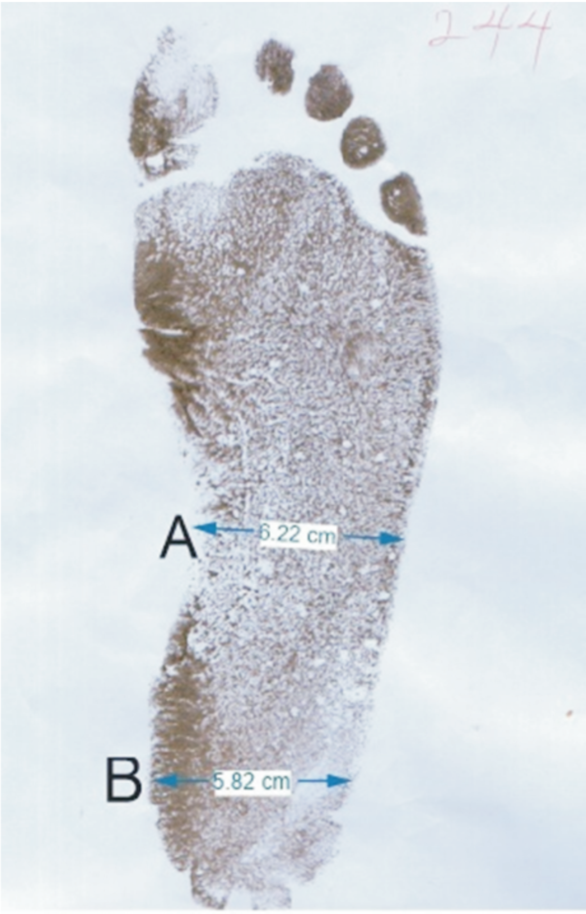

Figure 2: Method for measuring Staheli index as carried out in this study: SI=A/B

Data Analysis: Descriptive statistics (mean, standard deviation, minimum, maximum, frequencies) were used to examine the basic anthropometrical characteristics of the study population.

An independent samples test was used to compare group means and unpaired T-test was carried out to check for sexual dimorphism. Data were entered and all analyses were performed using constructed data sets in SPSS™ version 16.0 (SPSS Science, Chicago, Illinois) software package.

RESULTS

TABLE 1: Descriptive Statistics Showing Mean & Standard Deviation of Mid Arch Width (MAW) Width at Heel (WAH) & Staheli Index (SI) Irrespective of Age and Gender.

FOOT	PARAMETER	MEAN±SD	MAXIMUM	MINIMUM	NUMBER
RIGHT	MAW	5.40±1.59	9.48	1.73	218
	WAH	5.30±0.71	8.84	2.21	218
	SI	1.02±0.28	2.14	0.39	218
LEFT	MAW	5.46±1.56	9.38	1.68	218
	WAH	5.33±0.62	7.30	3.78	218
	SI	1.02±0.28	1.94	0.37	218

**There was no significant difference when comparing both feet irrespective of gender ($P \leq 0.05$)

TABLE 2: Descriptive Statistics Showing Mean ±Standard Deviation of Male and Female Mid Arch Width (MAC), Width at Heel (WAH), Width at Ball (WAB), Staheli Index (SI) Without Age Groupings.

SEX	FOOT	MAW	WAH	SI
MALE	RIGHT	5.88±1.51*	5.34±0.78	1.11±0.26*
	LEFT	5.89±1.46*	5.45±0.63	1.09±0.27*
FEMALE	RIGHT	4.99±1.55	5.26±0.65	0.95±0.27
	LEFT	5.09±1.55	5.23±0.60	0.97±0.28

*Values with similar superscripts are significant at $P \leq 0.05$

**MAW was higher in Males corresponding to a significantly higher SI when compared with Females.

TABLE 3: Shows the Distribution of Flat Foot (FF) Incidence And Mean±SD of Staheli Index of Male and Females According to Age Groupings for Both Left and Right Feet

AGE	SEX	FOOT (n=218)	SI (MEAN±SD)	NO. OF SUBJECTS WITH FF (%)	NO OF SUBJECTS WITH BILATERAL FF(%)	NO. OF FEET (left & right combined)
		RIGHT	1.21±0.12	6 (27.27%)		
	MALE	LEFT	1.17±0.15	3 (13.63%)	2 (9.1%)	44
6-9		RIGHT	1.07±0.20*	4 (11.11%)		
	FEMALE	LEFT	1.11±0.14	3 (8.33%)	2 (5.55%)	72
		RIGHT	1.07±0.23*	8 (15.38%)		
	MALE	LEFT	1.09±0.26	13 (25%)	5 (4.81%)	104
10-12		RIGHT	0.92±0.27	5 (11.9%)		
	FEMALE	LEFT	0.94±0.30	6 (14.28%)	2 (4.72%)	84
		RIGHT	1.06±0.39	5 (17.86%)		
	MALE	LEFT	0.95±0.28	4 (14.28%)	2 (7.14%)	56
13-15		RIGHT	0.82±0.28	1 (2.63%)		
	FEMALE	LEFT	0.81±0.28	1 (2.63%)	1 (2.63%)	76
TOTAL				59 (13.53%)	14 (6.42%)	436

**This table represents a summary feet analyzed and the number of flat feet observed in both genders across various age groups.

DISCUSSION

The height of the medial longitudinal arch of the foot has been one of the primary criteria when classifying foot structure and modifies significantly with growth and maturation [18].

The prevalence estimates of flat feet in children have been suggested to range from 0.6–77.9%, with consistent trends of reducing prevalence with increasing age [19]. This broad variation in prevalence estimates which has been explained as occurring due to a lack of consensus in the definition of flat feet and the lack of consistency in the measurement of foot posture, has been demonstrated by [20].

The method employed for obtaining footprints in this study is simple, not expensive, easy to apply and satisfactory for routine clinical analyses. It is clinically accepted that all typically, developing children are born with flexible flat feet, progressively developing a medial longitudinal arch during the first decade of life [21 & 22].

The results from the present study were surprising but not unexpected. Staheli Index was used to predict flat foot incidence according to the criteria set out by the Pediatric Orthopedic Society. The overall mean and standard deviation for Staheli Index of the subjects as recorded in table 1 for both right and left feet is 1.02±0.28. There was no significant difference between males and females as shown in table 2. The overall percentage of subjects with flat feet in the present study were 59 (13.53%) out of a total number of 436 feet analyzed. Of these number, males accounted for 39 (66.1%) of flat feet while females observed as having flatfeet were 20 (33.9%). This number differs significantly from a previous study by [11] on a sample size of 990 Port Harcourt school children with ages ranging from 5-14, they reported the prevalence of flat feet to be 2.2%. Similarly [12] also observed the prevalence of flat feet to be 11.2% within their study sample of 1000 Akwa Ibom youths aged between 20-30 years. These differences could be as a result of the larger sample size and different measuring techniques employed in their studies.

The distribution of flat foot incidence according to the various age groupings used in this study yielded some interesting findings. It has been verified by various authors that each child is born with flexible flat feet that gradually "normalizes" during the first decade of life. Hence there is a reduction in the number of incidence recorded in older populations [23, 24 & 25]. That was not the case in this study. We found out that there was no direct linear reduction in the number of those with flat feet. A possible reason for this disparity may be due to the fact the 2nd age group (10-12) had a disproportionately higher number of participants (94) than the other two sub groups (6-9 & 13-15) which had 56 & 68 number of participants respectively. Although foot dominance was not considered, we recorded a slightly higher number of flat feet on the left foot which was 30 (13.8%) than on the right foot which was 29 (13.3%).

The use of other indexes and sophisticated methodology such as, Chippaux-Smirak index (CSI), the FPI-6, contact II index, radiographic techniques and X-ray by some researchers yielded significantly variable prevalence results when compared with our own. [26, 27, 28, 29 & 30]. Therefore further studies employing these other indexes and techniques concurrently are required to test the validity of the already laid down protocols so that the most reliable method can be agreed upon for a more accurate diagnosis of pes planus.

This prevalence estimates serve as baseline data for podiatrist, shoe manufacturers and is can be helpful in clinical practice.

CONCLUSION

This study was conducted to check for the prevalence of flat feet of children in a Nigerian population using computerized measurements of mid arch width and width at the heel region. Our results showed that male (39) had a higher number of flat feet than females (20). The overall prevalence of flat feet was 13.53% in a sample of 436 measured feet. The computerized method employed in this study has been shown to have a higher accuracy, validity and reliability when compared to other methods employed in foot anthropometry.

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CONFLICT OF INTEREST

There is no conflict of interests.

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