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Predictive factors for flatfoot: The role of age and footwear in children in urban and rural communities in South West Nigeria

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ABSTRACT

Background: Flatfoot is common in children and its prevalence influenced by several factors. This study investigated the role of age and type of foot wear as predictors of flatfoot in school age children in urban and rural areas in south-western Nigeria.
Methods: 560 children between 6 and 12 years, divided into two groups; rural and urban were studied. Each subject's static footprint was taken on a white duplicating paper after which the instep was measured for classification into high arch, normal, flat or severe flat. The BMI of each subject was calculated from the anthropometric data. The type of footwear with which the subjects were shod was also recorded. Data analysis was by Epi Info statistical package version 3.5.1 (2008).
Results: Chi-square showed a significant ($p < 0.05$) association between the presence of flatfoot, age and type of footwear. Comparison of the prevalence of flatfoot by age group indicated a significant difference at age 10 years. Simple logistic regressions, however, showed that age was a significant ($p < 0.05$) predictor for flat foot while the type of footwear was not.
Conclusion: In this study, age is the primary predictor for flatfoot while the type of footwear is not.

1. Background

Flatfoot (Pes Planus) is a condition in which the medial longitudinal arch (MLA) of the foot collapses with the entire sole of the foot coming into complete or near-complete contact with the ground. A person with flat foot will usually have pronation of the mid foot and valgus of the hind foot [1].

Flatfoot is common in children though its prevalence has been found to decline as they grow. The incidence of flatfoot was found to be higher in school children of the affluent urban dwellers in India and studies have shown that people who wore shoes in early childhood were more susceptible to developing flat foot than those who did not [2]. In Austria however, no significant difference was found in he incidence of flat foot between preschool- aged population of urban and rural children [3]. Flexible flatfoot which is a developmental variation is a common finding in children under the age of 6 years but by the age 10 years, only a minority of children will have flat feet [2,4]. Studies have shown that longitudinal arches of bare footers were generally higher and flat feet were less common in children who had grown up without shoes than in those who had worn close toe shoes [2].

The prevalence of flatfoot in different groups of individuals as found in literature vary according to various factors, some of which are: age, sex, presenting medical condition, body composition, anatomical variation, types of foot wear and age at which shoe wearing began. The prevalence of flatfoot declines with age, being higher in children with ligament laxity and early shoe wearing has been found to impair longitudinal arch development [2]. On the other hand, recent studies have suggested that going bare footed on varying terrain can facilitate the formation of arches during childhood, with most people acquiring a developed arch between the ages of 4 and 6 years [5].

Several methods have been used to determine the presence of flat foot and some of these are X-ray imaging which is invasive, and Foot print method which is fast, non-invasive and simple, providing an indirect measurement of the MLA [6]. There are also several ways to grade the MLA [7–10]. Sachithanandam and Joseph [11] analyzed the static footprints of 1846 skeletally mature individuals to establish the influence of the age at which shoe-wearing began on the prevalence of flatfoot. The result showed that the incidence was 3.24% among those who started to wear shoes before the age of six years, 3.27% in those who began between the ages of 6 and 15 and 1.75% in those who first wore shoes at the age of 16 years. Flat foot was highest in those who, as children, wore footwear for over eight hours a day. Obese individuals and those with ligament

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laxity had a higher prevalence of flat foot while significantly higher prevalence was noted among those who began to wear shoes before the age of six years.

These findings suggest an association between flatfoot and the wearing of shoes in early childhood.

If most children in the urban areas are shod with close-toe shoes as against different types of footwear in the rural population, what role then does the type of footwear play in the prevalence of flat foot and does age have a predictive role in its prevalence? This study was undertaken to determine the predictive role of age and different types of foot wear on the prevalence of flatfoot among school children in the urban and rural areas in southwestern Nigeria. The result of this study might provide a basis for counseling parents on the choice of foot wear for their children.

2. Materials and methods

2.1. Subject selection

The subjects for this study were 560 school children with age between 6 and 12 years who did not have any obvious foot deformity or injury. The subjects were in two groups, urban and rural dwelling children.

Urban group This comprised of 285 children within the age range of 6–12 years in the staff children school of the University of Lagos, Akoka; Staff children school, Lagos University Teaching Hospital, and International school, University of Lagos, Akoka all in Lagos.

Rural group This comprised of 275 children within the age range of 6–12 years in 7 selected primary schools in Obafemi Owode Local government area of Ogun State, Nigeria.

2.2. Pre inclusion screening

All the subjects were screened for the following:

Deformities of the lower limb, history of fractures of the foot or any part of the lower limb that necessitated non weight bearing at the time of study, upper motor neuron disease, lower motor neuron lesion affecting the lower limb, oedema of the foot and sore or ulcer in any part of the foot.

2.3. Inclusion criteria

All subjects who were free of the above listed conditions were included in the study.

2.4. Exclusion criteria

The presence of any of the conditions listed above was the criteria for excluding subjects from the study thus six children were excluded from the study based on the criteria. The names of the subjects were not taken for the purpose of this study. The procedure was explained to the children after written consent was sought and obtained from the school authority in the urban area while in the rural area, consent was sought and obtained from the local education authority.

The ethical approval was sought and obtained from the Research and Ethical Committee of the College of Medicine, University of Lagos.

3. Methods

The sex and age as at last birthday was recorded for each of the subjects and the weight was recorded to the nearest 0.1 kg. The height was also recorded to the nearest 0.01 m. The BMI (body mass index) was calculated for each subject by dividing the weight by the square of the height. Data on the type of footwear worn by the subjects during school hours was also collated.

3.1. Foot print measurement

The foot prints of both feet of each subject was taken by making each subject step the bare foot one after the other on the foot pad which was soaked with non-permanent endorsing ink and then printing the foot on the white duplicating paper. This was allowed to dry after which the outline of the foot print was traced with a lead pencil and the foot prints were graded by measuring the instep at its widest part.

All footprints with instep less than 1 cm were considered flat, footprints with bulging (convex) medial border were considered severely flat. If the width of the footprint at its narrowest part is less than 1 cm, the foot was considered as high arch. All other footprints were considered normal [2,7,12].

3.2. Data analysis

The data collected was analyzed using the Epi Info statistical package programme version 3.5.1 (2008). Data collected were presented using descriptive analysis to determine the statistics of mean and standard deviation of the age.

Chi square analysis was used to compare the frequency of each sex in the two groups. Fisher exact test was used to compare the frequency of the different foot types in both groups.

Simple logistic regression of presence of flat foot on age, sex, and the type of footwear of subjects was analyzed. Multiple logistic regression of presence of flat foot on age, sex and the type of footwear of subjects was analyzed.

4. Results

A total of 560 children were studied. The Urban group comprised 285 subjects while the rural group comprised 275 subjects.

Subjects in the urban group all wore close toe shoes, i.e. 100%, but in the rural group, only 2.2% wore close toe shoes, 69.5% wore other forms of footwear while 28.4% wore no footwear at all. Chi-square showed a significant ($p < 0.05$) difference in the types of footwear between the two groups as shown in Table 1.

Foot types were compared in the two groups as shown in Table 1. Fisher's exact test showed that there was no significant difference in the right foot types of subjects in the two groups. However a significant difference was revealed in the left foot types of the subjects in the two groups.

Chi-square showed that there was no significant difference in the presence of bilateral flatfoot between the two groups, Fisher's exact test also showed no significant difference in the presence of high arch at $p < 0.05$ shown in Table 1.

The association between presence of flatfoot and age, sex and types of footwear was determined (Table 2). Chi-square revealed that there was a significant ($p < 0.05$) association between the presence of flatfoot and age, and also a significant ($p < 0.05$) association between the presence of flat foot and type of footwear but no significant association between sex and the presence of flatfoot.

In comparing the prevalence of flat foot by age among both population groups, it is seen in Table 3 that over half (51.2%) of the children in the urban areas presented with flat foot at 6 years of age as against 35% for the rural dwelling children though the difference was not significant. There is also a significant difference in the prevalence of flat foot at the age of 10 years.

Simple logistic regressions of presence of flatfoot on age, sex, footwear (Table 4) showed that only age and BMI were predictors

Table 1
Distribution of subjects by the types of footwear and foot type.

Foot type	Rural ($n=275$)		Urban ($n=285$)		χ^2	df	p	Fisher's exact p
	Frequency	%	Frequency	%				
Type of footwear								
Close-toe shoe	6	2.2	285	100	536.49	2	0.001*	
Others	191	69.5	0	0				
None	78	28.4	0	0				
Total	275	100	285	100				
Right								
High arch foot	1	0.4	2	0.7				0.092
Normal foot	239	86.9	226	79.3				
Flatfoot	33	12.0	53	18.6				
Severe flatfoot	2	0.7	4	1.4				
Total	275	100.0	285	100				
Left								
High arch foot	3	1.1	5	1.8				0.002*
Normal foot	232	84.4	209	73.3				
Flatfoot	40	14.5	65	22.8				
Severe flatfoot	0	0	6	2.1				
Total	275	100.0	285	100				
Bilateral flatfoot								
Yes	25	9.1	40	14.0	3.33	1	0.068	
No	250	90.9	245	86.0				
Total	275	100.0	285	100				
Presence of high arch								
Yes	4	1.5	5	1.8				1.00
No	271	98.5	280	98.2				
Total	275	100.0	285	100				

* Significant at $p \leq 0.05$.

Table 2
Associations between presence of flatfoot and age, sex and footwear.

Variable	Presence of flat foot (%)			χ^2	df	p-value
	Yes ($n=136$)	No ($n=424$)	Total ($n=560$)			
Age (year)						
6	35(40.7)	46(59.3)	81	25.71	6	0.0003*
7	27(31.0)	57(69.0)	84			
8	13(16.9)	64(83.1)	77			
9	24(29.9)	53(70.1)	77			
10	20(24.1)	59(75.9)	79			
11	17(12.3)	64(87.7)	81			
12	15(17.3)	66(82.7)	81			
Sex						
Male	76(26.8)	208(73.2)	284	1.29	1	0.238
Female	62(22.5)	214(77.5)	276			
Foot wear						
Close-toe shoe	90(30.9)	201(85.9)	291	14.51	2	0.001*
Others	30(15.7)	161(84.3)	191			
None	18(23.1)	60(76.9)	78			

* Significant $p \leq 0.05$.

Table 3
Comparison of the prevalence of flatfoot by age group between the rural and urban children.

Age (year)	Rural		Urban		χ^2	p-value
	n	Frequency (%)	n	Frequency (%)		
6	40	14(35.0)	41	21(51.2)	2.17	0.14
7	41	13(31.7)	43	14(32.6)	0.01	0.93
8	38	5(13.2)	39	8(20.5)	0.74	0.39
9	37	8(21.6)	40	16(40.0)	3.03	0.08
10	39	6(15.4)	40	14(35.0)	4.02	0.05*
11	41	7(7.3)	40	10(25.0)	1.18	0.28
12	39	5(12.8)	42	10(23.8)	1.62	0.20

* Significant $p \leq 0.05$.

Table 4
Simple logistic regressions of presence of flatfoot on age, sex, footwear and BMI.

Variable	Odd ratio	95% CI		β	SE	Z	p
		Lower	Upper				
Age	0.82	0.74	0.91	−0.20	0.05	−3.94	<0.001*
Sex (male/female)	1.26	0.86	1.86	0.23	0.20	1.18	0.239
Footwear (close toe/Others)	1.67	0.98	2.86	0.52	0.27	1.89	0.058
BMI-for-age-Z	1.18	1.03	1.35	0.17	0.07	2.38	0.017*

* Significant $p \leq 0.05$.

for flat foot while the type of footwear with which the children were shorn was not.

5. Discussion

The results of this study show foot wear type and age as factors influencing the prevalence of flatfoot among urban and rural dwelling children though the type of footwear was not a predictive factor. All the children in the urban area (100%) were shod with closed toe shoes while most of the children in the rural area (69.5%) were shod with other forms of footwear (Table 1). In contrast to some prior studies [11,13], sex does not influence the prevalence of flat foot in this study (Table 2).

The prevalence of flatfoot from the results of this study was significantly influenced by age. The highest incidence of flat foot in both populations was at the age of 6 years (Table 2) and over half of the children in the urban population (51.2%) presented with flat foot as against 35% in the rural population. Since the arches are normally developed between the ages of 4 and 6 years, this result might suggest a late development of the arches which could be attributed to the wearing of close-toe shoes especially in the urban children. This agrees with the study by Sachithanandam and Joseph [11] which suggested that the incidence of flat foot was highest in those who, as children, wore footwear for over eight hours a day and reported an association between early shoe wearing and flatfoot. This may be due to the fact that supportive shoes tend to limit the motion exercise of foot muscles which can lead to further flattening of the arch as a result of a weakening of the foot muscles. Shoe wearing in children may thus predispose to flat foot [2].

A recent study suggested that children who go barefoot have a lower incidence of flat foot and deformity while having greater foot flexibility than children who wear shoes [14] but it is interesting to note that contrary to these reports, as depicted in Table 3, the unshod had a higher prevalence (23.1%) of flat foot than those who wore other types of footwear (15.7%). This was also at variance with the study of Rao and Joseph [2] which also had the highest prevalence of flatfoot in subjects shod with closed toe shoes (13.2%), but was followed by those with other forms of footwear (6.0% and 8.2%). The least prevalence (2.8%) was found in unshod subjects. This also agreed with some prior studies that indicated that foot deformities were less common in unshod people and the longitudinal arches of bare footers were generally highest as a group [4]. This difference may be attributed to the fact that all the subjects in their study were rural dwellers whereas this study had both urban and rural groups.

According to Pfeiffer et al. [3], the natural history of flat foot is spontaneous improvement with increasing age. It is however seen from the result of this study that the incidence of flat foot declined sharply by age 8 years only to gradually increase from age 9 years with a significant increase by the age of 10 years. This agrees with prior studies that the normal findings of flat foot versus children's age estimate 45% of pre-school children, and 15% of older children at an average age 10 years have flat foot [15]. This may be attributed to obesity which results in ligamental laxity, both of which have been documented as risk factors for flat foot [11]. The significant prevalence of flat foot at age 10 among the urban dwelling children (Table 3) is quite pertinent as a study carried out by Koebnick et al. [16] on a cohort of multiethnic children indicated that extreme obesity peaks at 10 years of age especially in boys. This is expected because of the kind of lifestyle and diet the children in the urban areas are exposed to. This is however in contrast to some prior studies that indicated that only a minority of children will have flat feet by the age of 10 years [2,4]. The variance could be due to the fact that in these studies, only the rural population of children was studied while this study compared the rural with the urban population. Simple logistic regression analysis of the relationship between types of footwear and prevalence of flatfoot showed that even though the prevalence was significantly higher in subjects shod with closed toe shoes, footwear type was not a predictive factor for flatfoot (Table 4). Nevertheless, the results of this study have shown that closed toe shoes do have a significant impact on the prevalence of flat foot. This is quite pertinent as a child's foot size changes rapidly and foot growth continues to be very rapid in the first 5 years of life [17]. Before 18 months, feet grow more than half a shoe size every two months and a toddler's feet grow an average of half a size every three months. Until the age of 3 years a child's foot size increases by one size every 8 months and thereafter every year [12]. It is therefore important that shoes must fit the foot snugly at the heel preventing forward movement while walking [4,5].

In conclusion, early shoe wearing in children, coupled with overweight which may be related to age are factors which influence the prevalence of flat foot in children.

It is thus recommended that parents be counseled on the choice of footwear as well as weight control measures for their children.

Authors' contributions

AT carried out the field work. AA participated in the design and drafted the manuscript. TA and AS participated in the design of the study and performed the statistical analysis.

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