Title: Prevalence of pes planus and its associated factors among primary school pupils aged 8-12 years in southeast Nigeria

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Abstract

Background: Footprints of hominoids already demonstrated the existence of a plantar arch 3.7 million years ago, and, during human evolution, feet and not hands experienced extraordinary changes. The arch index is useful in determining the prevalence of pes planus and possibly predicting pathologic foot conditions, and it may serve as warning signs of structural and functional defects of the foot in a given population.

Objective: The purpose of this study was to evaluate the plantar arch index using the Staheli`s evaluation method and determine the point prevalence of pes planus and its association with sex difference, BMI, type of footwear and use of footwear early in life.

Method: This ex-post facto study involved 352 (150 males and 202 females) apparently health primary school pupils aged 8-12 years in southeast Nigeria who volunteered to participate in the study. The participants` biodata were obtained and their footprints collected with the ink method. Footprints were traced and selected foot dimensions measured on the footprints. Plantar arch index of each foot was calculated using the Staheli`s formula; PI=A/B, where PI= plantar arch index, A= central region of the footprint and B= heel region of the footprint. Data collected were summarized and analyzed with descriptive statistics of mean, standard deviation, percentage, chi-square and independent t-test, alpha level was set at 0.05

Results: Mean age of participants was 10.28±1.26 years while the mean body mass index was 17.60±2.81. Our results study revealed a low prevalence of pes planus (7.1%) in the population under study with males having slightly higher prevalence (4.3%) than females (2.8%). This study also found no significant association between gender (p= 0.114) and type of footwear (p= 0.314) and pes planus, but found a significant association between BMI and pes planus (p= 0.039).

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Type of first footwear (p=0.205), type of school footwear (p=0.819), type of home footwear (p= 0.714), early use of footwear (p=0.062), and frequency of footwear (p=0.170) use were not significantly associated with occurrence pes planus.

Conclusion: The prevalence of pes planus among primary school pupils aged 8-12 years in southeast Nigeria is not high and not of any health concern.

Key words: Staheli's Index; BMI; Pes planus; Footwear; Pupils

Introduction

The prevalence of pes planus (also known as pes planus) declines with age and higher in children with ligament laxity while early wearing of shoes impairs longitudinal arch development (Rao and Joseph, 1992). Pes planus was most common in children who wore closed-toe shoes, less common in those who wore sandals or slippers, and least in those who did not wear shoes (Rao and Joseph, 1992). Shoe wearing before the age of six has been shown to be another predisposing factor for pes planus (Mortazavi *et al.*, 2007; Sachithanandam and Joseph, 1995). One of the most commonly discussed topics in pediatrics orthopedics is the static-postural changes of the feet. The foot and ankle have been described as an elastic arched structure with the keystone of the arch being the talus (Luttgens and Hamminton, 1997). The foot consist of 26 bones; seven tarsals, five metatarsals and 14 phalanges (Moore and Dalley, 2006). The foot and ankle also contain 23 joints, less than 100 muscles, tendons, ligament and a network of blood vessels, nerves, skin and soft tissues. The normal foot has two significant arches, the transverse and the longitudinal arches. The longitudinal arch of the foot is further subdivided into a medial and a lateral longitudinal arch (Sinnantamby, 2006). These arches act as shock absorbers, helping in supporting the body in the erect posture and are also important in propulsion during gait (Greenstein, 1997).

The concept of arch index was first described by Cavanagah *et al.*, (1987) as the ratio of the area of the middle third of the foot to the entire foot area excluding the toes. An arch index of less than 0.60 has been said to be indicative of a cavus foot, when greater than 0.70, it is indicative of planus foot and arch index between 0.6-0.7 is considered normal arch height. The assessment of plantar arch index using the relationship between central arch width and heel region width obtained on a footprint was proposed by Engel and Staheli, 1974. The arch index is useful in determining the prevalence of pes planus and possibly predicting pathologic foot

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conditions and it may serve as warning signs of structural and functional defects of the foot in a given population (Igbidi et al., 2005).

Pes planus describes a condition in which the longitudinal (length wise) and/or the medial arch (cross wise) arches of the foot are dropped down or flat, the entire bottom of the bare foot is in contact with the floor or ground surface during standing, walking or other weight bearing activities. Pes planus is a biomechanical problem consisting of a constellation of physical features that includes excessive eversion of the subtalar complex during weight-bearing, with plantar flexion of the talus, plantar flexion of the calcaneus in relation to the tibia, dorsiflexion and abduction of the navicular, supination of the forefoot, and valgus posture of the heel (Canale, 2003). Humans are born with pes planus and develop arches throughout childhood. The flat appearance of the foot before age three is normal and results partly from the thick subcutaneous fat pad in the sole of the foot which masks the developing arch and partly because the arches are not yet fully developed (Umar and Adeyemi, 2010). Pes planus deformity is frequently encountered in paediatric orthopedics and rehabilitation practices. People with pes planus are at higher risk of foot pain, knee pain, foot injury, stress fracture, hammertoes, bunions, shin splints, arthritis of foot joints, plantar fasciitis, tendonitis and poor exercise performance (Omey and Micheli, 1999).

Research suggests that the optimal age range for arch development is 4-6 years old and that arches are usually formed completely by age 8 (www.bienetrespa.com).

In Brazil, Volpon presented the results of footprints of 637 individuals between zero and 15 years old. The study revealed that plantar arch shows a great deal of development up to the 6th year of life, increasing little after that age. It also reports the stabilization of pes planus incidence at around 2% (Volpon, 1989). Wearing shoes at too young an age can impede the tactile ability of feet and limit proper growth of muscles and tendons needed for proper arch development to occur (www.bienetrespa.com). According to a research conducted in India to

analyze static footprints of 2300 children, the incidence among children who used footwear was 8.6% compared with 2.8% in those who did not ($p < 0.001$). Significant differences between the predominance among children who used footwear and those who did not were also noted in all age groups, most marked in those with generalized ligament laxity. Some researchers have pointed out sex preponderance as a factor predisposing to pes planus (Lin *et al.,* 2001; Eluwa *et al.,* 2009). According to a research conducted by Pfeiffer et al (2006), boys had a significant tendency for pes planus than girls: the prevalence of pes planus in boys was 52% and 36% in girls. Ezema *et al* (2013) demonstrated that male children were twice as likely to be affected by pes planus as their female counterparts, the higher incidence of pes planus among male children could be explained by the greater rear foot valgus and retarded development of rear foot in boys compared with girls.

The weight status of a person has been found to be significantly associated with pes planus. Obese children are three and a half times more likely to be diagnosed with pes planus compared with children of normal weight (Ezema *et al.,* 2013). A similar association has been reported by previous studies conducted in other countries (Sobel *et al.,* 1999, Pfeiffer *et al.,* 2006 and Chang *et al.,* 2010). The effects of temporary loading intensity on foot biomechanics have been examined and obesity during childhood has been shown to relate to certain dimorphism of the foot, particularly pes planus (Cavanagh *et al.,* 1987, Bordin *et al.,* 2001). However, not much has been reported on the long-term loading effects of obesity on the developing longitudinal arch of growing children (Dowling *et al.,* 2001). Nevertheless, it cannot be ruled out that the high prevalence of pes planus in overweight and obese children may be related to the continued pressure exerted on the longitudinal arch during gait.

The objective of the present study is to investigate the prevalence of pes planus amongst children aged 8 - 12 years in Nnewi North Local Government Area of Anambra state, and the

influence of age, sex, body weight, type of footwear and early footwear on the development of pes planus.

Methods

Participants

Participants were from a population of 26,712 apparently healthy pupils from 147 primary schools. The sample size of this study was obtained using the Taro Yamane formula (Ndupu, 2008) which is stated as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where, 1= unity; e= level of significance or limit of tolerable error=0.05, N= population

$$n = \frac{26712}{1 + 26712(0.05)^2}$$

and n = sample size n=394

Participants comprised primary school pupils in between 8-12 years of age, both males and females who agree to be part of the study. Participants must be officially enrolled in a primary school, within the age range of 8-12 years old, without any deformity of the foot or lower limbs (except pes planus), without any history of previous neuromuscular skeletal pathology of the foot or the lower limbs, and no history of past surgery on the feet. Two hundred and twenty-four females and 170 males who satisfied these inclusion criteria and consented were included in the study. However, 42 pupils were eventually excluded because they returned their biodata forms unfilled thereby reducing the total number of participants to 352.

Data collection

Ethical approval was sought and obtained from the institutional review committee of Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nigeria. The informed consent of the parents of participants was obtained before the commencement of the data collection. A biodata form was completed by the parent (preferably the mother) of each of the participants. While seated, the

participant's foot already dipped in an endorsing ink, was placed on the plain duplicating paper with the contra lateral foot off the platform. The participant then stood up and performed a small flexion of the ipsilateral knee above 30^0 this was to ensure that a clear footprint was obtained (Hernandez et al., 2007). The footprint was used to calculate the plantar arch index. The plantar arch index establishes a relationship between central and posterior (heel) regions of the footprint, and it is calculated as follows: a line is drawn tangent to the medial fore foot edge of the heel (Staheli et al., 1987). The mean point of this line is measured and marked off; a perpendicular line is drawn crossing the footprint. The same procedure is repeated for the heel tangency point (Hernandez et al., 2007). The measurement of the support width of the central region of the foot (A) and the heel region (B) in millimeters is obtained. The plantar arch index (PI) is calculated by dividing the A value by B value: (PI=A/B) (Staheli et al., 1987). A normal plantar arch index (PI), according to orthopedic society is the one comprised within two standard deviation (2SD) of the population average mean. The PI value equal or above the sum of 2SD with the mean was considered as indicative of pes planus and threshold indexes for this condition in the population under study (Staheli et al., 1987).

Data analysis

Descriptive statistics of mean, standard deviation and percentage was used to summarize the data obtained. Independent t-test was used to determine the difference between the right and left plantar indices obtained from the footprints and to determine the sex difference of the right and left plantar indices. Chi square was used to determine the association between type of footwear and the occurrence of pes planus and the association between early footwear and the occurrence of pes planus. SPSS version 21 was used and alpha level was set at 0.05 level of significance.

Result

Three hundred and fifty two participants (202 females and 150 males), who met study criteria were involved in the study. Table 1 revealed point prevalence of pes planus as 7.1% (25 out of 352) among participants with a slightly higher prevalence in males (15 out of 150, 10%) than in females (10 out of 202, 5%) (p=0.11). Point prevalence of pes planus was 7.1%.

Table 1: Point prevalence and gender distribution of pes planus

Variable	Normal foot n(%)	Pes planus n(%)	p-value
Males (150)	135(90)	15(10)	0.114
Females (202)	192(95)	10(5)	
All participants (352)	327(92.9)	25(7.1)	

Key: n= number of participants, % = percentage, p= level of significance

Table 2 shows the mean values for measurement of central width support(A), heel width support (B) and of the plantar arch index (PI) of the foot measurements in centimeters, comparing same side of foot between male and female and opposite side of foot within the general population sample. The plantar arch index (PI) is the ratio of A to B (PI=A/B). There was no significant difference (p = 0.352) between the right plantar arch index (PI) of male and female foot of primary school pupils.

Table 2: Descriptive statistics of the measurement of selected foot dimensions

Variables	Right foot	Left foot	t	p-value
	Mean±SD	Mean±SD		
All participants(n=352)				
A	4.225 ± 0.612	4.549 ± 0.742		
B	4.936 ± 0.815	4.825 ± 0.522		
PI	0.822 ± 0.192	0.818 ± 0.178		
Males (n=202)				
A	4.114 ±I.053	3.945 ± 0.965	0.933	0.352
B	4.868 ± 0.538	4.767 ± 0.523		
PI	0.839 ± 0.189	0.830 ± 0.166		
Females (n=150)				
A	3.953 ± 1.010	3.937 ± 0.973	0.503	0.615
B	4.901 ± 0.512	4.847 ± 0.521		
PI	0.817 ± 0.191	0.819 ± 0.180		

Key: PI = plantar arch index; N = number of participants; SD = standard deviation; t = independent t-test

There was also no significant difference (p = 0.615) between the left plantar arch index (PI) of male and female foot of primary school pupils.

Table 3 shows no significant association between sex difference and pes planus. But the males had slightly higher prevalence (15 out of 150, 10%) than the females (10 out of 202, 5%).

Table 3: Association between sex difference and pes planus

Variable	Normal foot	Pes planus			X^2	p-value
		Unilateral	bilateral	total		
Males (n=150)	135	9	1	10	4.349	0.114
Females (n=202)	192	11	4	15		

Key: n = number of participants, p = level of significance; X^2 = Chi-Square Test

Table 4 shows a significant association between pes planus and BMI. Pes planus was found to be most prevalent amongst the obese individuals (7.3%) and least prevalent amongst the underweight individuals (5.8%).

Table 4: Association between BMI and pes planus using Chi-Square test

Variable	Normal	Pes planus	Total	X^2	p-value
Underweight	32(94.2%)	2(5.8%)	34	4.349	0.039
Normal weight	246(92.8%)	19(7.2%)	265		
Overweight	38(92.7%)	3(7.3%)	41		
Obesity	11 (91.7%)	1(8.3)	12		

Ten percent of those who wore cover shoe first had pes planus, 8.5% of those who wore canvas first had pes planus, 3.0% of those who wore sandals first had pes planus, and 0% of those who wore slippers first had pes planus. However, first footwear was not found to be significantly associated with pes planus. Approximately 11% of those who wore cover shoe more frequently had pes planus, 4.8% of those that wore canvas more frequently had pes planus, 8.7% of those that wore sandals more frequently had pes planus and 3% of those that wore slippers more frequently had pes planus. Again, frequently used footwear was not found to be significantly associated with pes planus. About 10% of those who wore cover shoe to school had pes planus, 11.0% of those who wore canvas to school had pes planus, and 5.7% of those who wore sandals to school had pes planus. Twenty percent of those who wore sandals at home had pes planus while 6% of those who wore sandals at home had pes planus.

Table 5: Association between type of footwear and pes planus

Variable	Cover shoe		Canvas		Sandals		Slippers		X^2	p
	NF	FF	NF	FF	NF	FF	NF	FF		
FFW	90	10	91.5	8.5	97:	3	100	0	10.943	0.205
FEFW	89.5	10.5	95.2	4.8	91.3:	8.7	97	3	11.592	0.170
SFW	90.5	9.5	89	11	94.3:	5.7			2.915	0.819
HFW					80:	20	4	6	5.569	0.062

Key: NF = normal foot, FF = pes planus, FFW = first footwear, FEFW = frequent footwear, SFW = school footwear, HFW = house footwear

Table 6 shows no significant association between early footwear and pes planus, although the prevalence of pes planus was higher in the age group 1-10 months (17 out of 194 persons, 8.76%) than in the age group 21-50 months (1 out of 33 persons, 3.03%).

Table 6: Association between early footwear and pes planus

Age groups	NF	FF(u)	FF(b)	X^2	p-value
1-10 years (n=194)	177 (91.2%)	15(7.7%)	2(1%)	5.398	0.714
11-20 years (n=125)	118(94.4%)	5(4%)	2(1.6%)		
21-30 years (n=27)	26(96.3%)	0(0%)	1(3.7%)		
31-40 years (n=5)	5(100%)	0(0%)	0(0%)		
41-50 years (n=1)	1(100%)	0(0%)	0(0%)		

Key: NF: Normal foot, FF(U): Unilateral pes planus, FF(B): Bilateral pes planus, n: Number of participants,

Discussion

In a sample of 352 participants, only 25 participants had pes planus, of whom 20 had unilateral pes planus (9 girls, 11 boys) while 5 had bilateral pes planus (1 girl, 4 boys). The prevalence of pes planus in this age group was low. There was no significant difference between the right and left plantar arch index (PI) of male and female foot even though that of the males were slightly higher than that of females. The prevalence of pes planus among different age groups in Nigeria and other parts of the world remain controversial, largely because of different criteria used in identifying pes planus. Umar et al., 2010 conducted a study on paediatric pes planus in Yoruba ethnic group of Nigeria and found the prevalence to be as high as 25% with 13% in males and 12% in females. Didia *et al*., (1987) investigated the prevalence of pes planus among school children in south-south, Nigeria. In that study, the prevalence of unilateral Pes planus was found to be 2.22%. Orji (2011) in her study to investigate the prevalence and types

of pes planus amongst undergraduates in a southeastern Nigeria University found the prevalence to be 3.8%, she also found no significant difference in the plantar arch index between the right and left foot while Chidozie (2012) found that the plantar arch index of the males` was significantly higher than that of the females, this may be due to the difference in age groups studied. However, after the estimation of the plantar arch index indicative of pes planus (PI=1.20 for the right and PI=1.17 for the left) using the criterion proposed by the paediatric orthopedic society in which a PI value equal or above the sum of 2SD with the mean was considered as indicative of pes, it was discovered from observation that some footprints that were visibly pes planus were not captured because they had values lower than the pes planus value obtained using the criterion.

Association of pes planus and gender

In this study, there was no significant association between the occurrence of pes planus and gender. , This findings is in agreement with the study done in the Yoruba ethnic group of Nigeria where the overall incidence percentage of pes planus among the total population studied (200 school aged children) was as high as 25% with 13% in males and 12% in females (Umar *et al.,* 2010). Other studies have however reported association between prevalence of pes planus and gender. In two studies (Chang *et al.*, 2009; 2010) in a Taiwanese population, males had a higher percentage prevalence than females. In another study, Eluwa *et al* (2009) reported that the prevalence of pes planus among the Southern Nigeria was higher in females. Although sample size in these studies and geographical regions of the study population could have been factors, the higher incidence of pes planus among male children can be explained by the greater rear foot valgus and retarded development of rear foot in boys compared with girls. Conversely, the higher prevalence among females may also be due to the fact that adult females tend to have small bones and less bulky muscles, since both factors help in the maintenance of the arches of the foot (Hicks, 1955).

Association with body weight

This study revealed the association between body weight and pes planus. Prevalence of pes planus was found to be highest amongst overweight children, followed by normal weight children and least in underweight children. This is in agreement with the study done by Ezema *et al.,* 2013 in which obese children were three and a half times more likely to be diagnosed with pes planus compared with children of normal weight. This high prevalence of pes planus in overweight and obese children may be related to the continued pressure exerted on the longitudinal arch during gait. The weight of a person has been found to be significantly associated with pes planus. The effects of temporary loading intensity on foot biomechanics have been examined and obesity during childhood has been shown to relate to certain dimorphism of the foot, particularly pes planus (Cavanagh et al., 1987, Bordin et al., 2001). However, not much has been reported on the long term loading effects of obesity on the developing longitudinal arch of growing children (Dowling et al., 2001).

Association with type of footwear

Pes planus percentage was found to be highest in children who started life by wearing cover shoes, followed by those who wore canvas, with the least percentage of pes planus found in those that wore sandals. Those who wore cover shoe more frequently had the highest percentage of pes planus occurrence, followed by those who wore sandals more frequently, then those who wore canvas more frequently with the least occurrence found in those who wore slippers. Out of the 352 participants, 262 said they wore specific footwear to school. Amongst them, the canvas wearers had the highest percentage prevalence of pes planus followed by the cover shoe wearers, and the least occurrence was amongst the sandals wearers. Out of the 352 participants, 326 wore footwear at home. Amongst them, 20% of those who wore sandals at home had pes planus while 6% of those who wore slippers at home had pes planus. None wore cover shoe or canvas at home.

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In summary, pes planus was found not to be significantly associated with type of footwear. However, those who wore closed-toe shoes (cover shoe and canvas) had higher prevalence of pes planus than those who wore sandals, and those who wore sandals had higher prevalence than those who wore slippers.

This study is in agreement with the study done by Sachithanandam *et al*., (1994) in India which found that subjects who wore slippers or sandals before six years of age had a lower prevalence than those who used closed-toe shoes, but this difference was not statistically significant, and also with the study conducted in the south western Nigeria involving 560 children between the ages of 6-12 years, the study showed that age was a significant predictor for pes planus while type of footwear was not (Abolarin *et al*., 2011). But this study is in variance with the study done by Rao *et al*., (1992), with 2300 children aged 4-13 years which found a significantly high prevalence of pes planus amongst children who wore closed toe shoes, a low prevalence amongst those who wore sandal or slippers and least prevalence amongst those who went barefoot, this variance may be attributed to large sample size of this study compared to the present study.

Association between early footwear and pes planus

The prevalence of pes planus is higher in those who started using footwear between ages 1-10 months than in those who started using footwear between the ages 21-50 months. This study showed no significant association between age of first footwear and pes planus, even though the prevalence was higher in those that started using footwear in their first year of life.

The result of this study is in agreement with the study conducted in India by Sachithanandam et al., (1994) in which the prevalence of pes planus in those who started using footwear before the age of five years was 3.24%, 3.27% in those who began between the ages of 6 and 15 years and 1.75% in those who first used shoes after the age of 16 years. However, this study found a significant association between pes planus and early footwear, which is in variance with the

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findings of the present study. This variance may be due to much higher prevalence of pes planus, higher sample size and difference in race.

Conclusion

The main finding of this research shows that the prevalence of pes planus in the age group studied is not high and not of any health concern.

Recommendations

1. More studies should be done in Nigeria to investigate the association between pes planus and footwear using larger population.
2. Prospective researchers should make efforts to reveal the foot status of each participant to him/her with respect to the foot condition under study.
3. Prospective researchers in this field should incorporate into the study an intervention plans, advice and education for those participants found to have the deformity.
4. The evaluation criteria by the paediatric orthopaedic society should be reviewed to confirm its reliability in the evaluation of pes planus.

Conflict of interest: None

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