# **Assessment of Flat Foot Using Chippaux–Smirak Index Among School Children in Asaba, Delta State, Nigeria**

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**ABSTRACT**

**Introduction:** Flat foot is usually an indication of a very low foot arch. The development of foot arch is brisk between ages 2 and 6 but becomes structurally perfected around age 12 or 13. This study assessed Flat foot in school children aged 6-12 years in Asaba metropolis, Delta State, Nigeria.

**Materials and Methods:** This quantitative and descriptive cross-sectional survey employed the use of 350 children (175males and 175females) who were randomly selected. Foot prints were obtained by the ink and plain paper method. Measurements of the parameters for the index were made on the prints and Chippaux-Smirak index (CSI) was thereafter calculated according to a previously recommended method. Paired samples T-Test was used for determining differences between the right and left feet while Chi-square was used to determine gender differences.

**Results:** Results showed that the mean CSI for the right and left foot were 41.90±0.69 and 42.29±0.69 respectively. There was no statistically significant difference between flat foot of the right side and that of the left (p>0.05). Also, there was no statistically significant gender difference in flat foot on both foot sides. Normal arch was most prevalent with 48.6%, while flat foot (36.4%) was more prevalent than high arch (15.0%). Flat foot, high and normal arch types showed no sexual dimorphism in the studied population**.**

**Conclusion**: This study has shown that flat foot is more common in females than in males among children between 6 and 12years in Asaba, Delta State, Nigeria. Thus, further studies on the effects of nutrition on flat foot should be conducted in the studied population.

**Keywords:** Asaba, Chippaux-Smirak Index, Flat Foot, Footprints

INTRODUCTION

Flat foot (Pes planus) is a common postural deformity characterised by the presence of an incomplete or total loss of the arches of the foot 1. It is said that the foot arch is the main supportive foot structure which provides an elastic base for weight bearing forces transmitted from the knee to spread evenly 2. It is also said that foot arch development is abrupt between the age of two and six but becomes structurally perfected around the age of twelve or thirteen years 1. Therefore, its prevalence abruptly declines with age as a result of walking and other child activities. A study in Rawalpindi/Islamabad 3 showed physical activity is directly proportional to the medial longitudinal arch development. Pes planus is said to be higher in children with ligament laxity while early shoe wearing impairs longitudinal arch development 4. It is reported that a higher occurrence of Pes planus is seen in males than females 5. It was reported that boys (52%) had a significant greater tendency for flat foot than girls (36%) in a previous study 6. A similar study carried out amongst school children in Enugu revealed that male children were more affected compared to their female counterparts 7. However, flat foot was more prevalent in female school children in Benin City as reported previously 8. Flat foot is often associated with displacement of the head of the talus bone with a concomitant stretching of the spring ligament resulting in loss of functionality of the medial longitudinal arch. Children with Pes planus easily develop musculoskeletal pain around the back, hip and knee regions, and 30% of those born with flat foot present with a deformity referred to as calcaneovalgus feet 5. Several causes of Pes planus have been accounted for, which may include but not restricted to obesity, posterior tibial tendon dysfunction, tarsal coalition, peroneal spasticity, post traumatic arthritis, charcot foot and neuromuscular in-coordination 9. Significant differences in predominance of flat foot between overweight, obese, and normal-weight children were observed in some previous studies 6, 10. In the same vein, another previous study 7 observed a statistically significant relationship between weight and flat foot as obese children were susceptible to this deformity while age was shown as the primary predictor for flat foot rather than type of footwear among subjects of South Western Nigeria in another study 11. Furthermore, it has been shown that the prevalence of flat foot decreases significantly with age6 and that in the group of 3-year-old children, 54% showed a flat foot, whereas in the group of 6-year-old children only 24% had a flat foot6. Previously, a study stated that the prevalence of flat foot was 16.1% with a decreasing trend with age10. An Iranian study 12 showed most of the respondents (789 cases) were diagnosed of Pes planus (48%).

Thus, this study assessed flat foot using Chippaux-Smirak index among three hundred and ninety (390) school children between ages 6 and 12 with regard to gender in Asaba, Delta State, Nigeria. Asaba is the capital of Delta State located on the Western end of River Niger with a population of about 149,603 as at the 2006 census (Federal Republic of Nigeria: 2006 Population Census, Wikipedia, 2019), it is a highly commercial city with a crop of versatile professionals with rich cultural affiliation. It is the major border between the state and its eastern neighbours; hence there is active migration from rustic areas into the city 13-14. Due to paucity of data and sometimes unavailable literatures on the subject matter in this part of the world, a timely investigation of flat foot among school children in Asaba, Delta State is pertinent.

MATERIALS AND METHODS

The population size of Asaba (GPS coordinates of 6° 12' 21.3444'' N and 6° 41' 45.2184'' E) as stated in the aforementioned as revealed by the Federal Republic of Nigeria in the 2006 Population Census report was retrieved from the records of the Delta State Local Government Area Secretariat at Asaba in order to effectively calculate the sample size. Thus, three hundred and fifty (350) subjects (175 males and 175 females) were used for this study in regards to the procedures for sample size calculation recommended by Krejcie and Morgan (1970). Several primary schools in Asaba were randomly selected by balloting while participants of both genders were pupils/students who were also randomly selected from each class (from primary to junior secondary) in the different schools that were chosen. Children with foot deformity or those who have undergone any evident foot or leg surgery were excluded. Also, Children below 6 years and above 12 years and those who were unable to stand erect without support were excluded.

The main goal of the study was to assess flat foot occurrence in school children aged 6-12 years in Asaba, Delta State, Nigeria. Thus, the specific objectives were to determine; flat foot using Chippaux-Smirak Index amongst school children between ages 6 and 12 years, any age and/or gender differences in flat foot using the chosen index as well as to ascertain any difference between flat arch and normal arch.

In obtaining a footprint, the participants’ feet were thoroughly cleaned in a sitting position and placed on a clean tile while a separate tile was impregnated with blue washable non-toxic stamp ink (Ready 2 Learn, CE504, 2019) and spread evenly using a roller brush. The subject was asked to step onto the tile filled with ink. The foot of the subject was then removed from the tile and he/she was asked to stand erect to make an imprint on a sheet of A4 paper. Foot prints were obtained for both right and left feet. Methylated spirit and cotton wool were used to wipe the ink off the foot after the procedure. The use of acetone was avoided assuming there were undisclosed allergies as well as the tender nature of a child’s skin. The ratio of the minimum width of the arch to the maximum width of the metatarsals was used as Chippaux-Smirak index (CSI). A lead pencil and a metre rule were used to draw the parallel lines across the narrowest part of the midfoot (line B) and widest part of the forefoot (line A). Thus, CSI = B/Ax100%. Thereafter, the foot was then classified into various types of arches into; flat (≥ 45%), normal (30% - 44.9%) and high (0.1% – 29.9%) arches based on a modification on previous classifications15-17.

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Data analyses were carried out using the Statistical Package for Social Sciences (SPSS v.22). Independent samples t-test was used to determine any statistical gender difference while correlation was used to determine the relationship between age and flat foot. Paired sample t-test was used to determine differences between right and left flat foot. P value less than 0.05 was considered significant. The results were presented in tables and charts.

RESULTS

Demographic data of the study reported that both males and females had equal number (n=350) of participation (n=175, 50% each) while Chippaux-Smirak index was used to assess flat foot. The combined parameters of the study are shown in table 1.

**Table 1: Combined Parameters of Subjects**



**\*CSI = Chippaux-Smirak Index, S.E = Standard Error**

Thus, table 1 showed that CSI for the right foot ranged from 12.90 – 84.90, while the left ranged from 11.80 – 84.20. Next, there were comparisons of both genders on both right and left sides using CSI (see Table 2).

**Table 2: Gender Comparison of Flat Foot using Chippaux-Smirak Index**



**\*S.E = Standard Error of Mean**

Table 2 shows that the CSI for the right foot was higher among males while the CSI for the left foot was higher among the females. However, these differences were not statistically significant (p>0.05).



**Figure 1: Distribution of Foot Types on both Right and Left Sides**

On the right foot, most of the subjects had a normal arch (n=175, 50.0%) next to flat foot (n=123, 35.2%) while high arch was least (n=52, 14.8%) (See figure 1). Also on the left side, most of the subjects had a normal arch (n=165, 47.1%) which was followed by flat foot (n=132, 37.7%) while the least was high arch (n=53, 15.1%) (See figure 1).



**Figure 2: Prevalence of Flat Foot using Chippaux-Smirak Index**

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The total prevalence of flat foot as shown in figure 2 was 36.4% while that of high arch and normal foot were 15.0% and 48.6% respectively. Thus, the prevalent foot type in the study population is normal foot.

**Table 3: Prevalence of Foot Types based on Gender**



*P (right)*= 0.712, *P (left)* = 0.894

On the right foot as shown in table 3, normal arch was more common among males than their female counterparts while flat foot was more common among males than their female counterparts in the studied population. Additionally, on the left foot, normal arch was more common among females than their male counterparts while flat foot was similar in occurrence among both genders in the studied population. However, these differences were not statistically significant.

**Table 4: Relationship between Age and Flat Foot using Chippaux-Smirak Index**



Table 4 showed negative correlation between ages 6-12yrs and flat foot on both right and left sides.

**Table 5: Differences in Flat Foot between Right and Left Sides**



As shown in the table 5, the mean CSI of the left foot was lower than that of the right foot.

DISCUSSION

Flat foot in children is a developmental phenomenon that is corrected with age as a result of maturation of the muscles and tissues 6, 18. Previous Researchers 19-23 have used different methods (e.g. Chippaux-Smirak index, Staheli Index, Plantar arch Index, Contact Index II, Navicular Drop Test, Foot X-ray, Direct Foot Scans using HP Photo Scanner with scanning software, or children footprint with ink) to diagnose flat foot. However, this study employed the use of Chippaux-Smirak index for flat foot assessment.

The prevalence of flat foot obtained from this study was 36.4% and was found to be synonymous to a previous report 24, where the mean prevalence of flat foot was 34.9% among Iranian children between 6 - 11 years of age. This report confirms the notion that the percentage of flat foot in children is generally high worldwide and that more than 30% of children have the flat foot defect 5.

Other studies demonstrated a prevalence range of flat foot of between 2.7% for 3-6-years old children in Vienna, Austria 6, 44% for 4 to 13 years old school children in Malaga, Spain 25 and 16.1% for 6-18 years old children in Babol, Iran 10. The prevalence of flat foot in the current study was higher in females (21.5%) than in males (16.7%) but the difference was not statistically significant. Previously, a study 26 reported that the percentage of flat foot in their series of school students was 18% in boys and 14.6% in girls. In other studies, however, the prevalence of flat foot in girls was higher than that in boys 27-28. One of the studies 29 reported the prevalence of flat foot in female as 75.2% and 72.6% in males. Discrepancies in the result of this current study and that of previous studies 27-29 may be as a result of the fact that females have smaller bones and less bulky muscles 30; and they wear closed-toe shoes that may be detrimental to the development of the arches of the foot 30.

Contrary to the results of other studies, this study found no significant association between age and flat foot. This finding contradicts a study that stated that flat foot in children could be a physiological phenomenon which could be corrected with time through muscle and tissue development 25, 31. A decreasing trend in the prevalence of childhood flat foot with an increasing in age was detected in a previous study 10. Other studies evaluating the prevalence of flat foot among school-age children based on disparate criteria have indicated a prevalence ranging from 17% in 9 years old 32, 35.5% in 6-11 years old 27, and 58.7% in 7-12 years old children 33. In another study 34, the prevalence of flat foot in Iranian school-age children was 74% (being mild in 23%, moderate in 34%, and severe in 17%) indicating that flat foot is a common problem among primary school-age students. In another study 18, it was determined that flat foot prevalence declined by increasing age in preschool-age children. These discrepancies may be attributed to the fact that the age range used in the index study was below childhood age range.

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There was significant positive correlation of flat foot between the right and left feet. Thus, flat foot in one foot (unilateral) could indicate flat foot in the other foot (bilateral). This result is in line with some previous studies. In the study conducted on flat foot and associated factors among primary school children in Enugu, Eastern Nigeria, one hundred and six (22.4%) students had flat foot, 93 (87.7%) of which were flexible, and 97 (91.5%) students had flat foot on both sides 7. However, a previous study 35 differs from the current study where they

reported that unilateral flat foot was more common than bilateral flat foot. This could possibly be as a result of use of contact index II for assessment of flat foot in that study while this study employed Chippaux-Smirak index. In another study 22, 3 (6%) members had unilateral left flat foot and 1 person (2%) had unilateral right flat foot and the remaining 4 subjects had bilateral flat foot (8%). To the best of the researchers’ knowledge, most previous studies at the time of this research did not focus on comparing flat foot on both right left sides.

The dissimilarities obtained in the treatise when compared with the upshot in previous studies could be ascribed to several factors, which may not have been studied in the present work or earlier, such as, absence of a common or standardized assessment, inadequate experience on footprint calculation based on the index used and analysis, gender, age range, obesity, footwear, race and heredity, activity, and even environment.

**Conclusion**

The findings of this study are of great relevance to Paediatricians, Orthopaedic Surgeons and Cobblers in the shoe-making industry thereby designing special models for flat footed individuals. Also, the present study has added to the existing data on prevalence of flat foot among school children in Nigeria

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