

Assessment of Plantar Arch Index and Prevalence of Pes Planus Among Adolescents: A Survey Study



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Abstract

Introduction: Pes planus is a foot condition which emerges when the medial longitudinal arch of the foot is absent or reduced. The study examined the prevalence of pes planus among adolescent population in Owerri using PAI as a parameter for assessment and risk factors associated with it among the population.

Methods: A cross-sectional study design of 160 adolescents ranging from 10 to 19 years was used. The data collection process incorporated measurements of the plantar arch index (PAI) utilizing the ink method, alongside the collection of demographic information and anthropometric measurements. Statistical analyses including t-tests and correlation analyses with alpha level set at $P < 0.05$ were used to evaluate the prevalence of pes planus, categorize foot arch types, and investigate potential associations with age, gender, and Body Mass Index (BMI).

Results: The study revealed that pes planus was significant among adolescents in Owerri, with 37.5% of participants exhibiting this condition. Others had either normal arches (50.6%) or high arch (11.9%). Furthermore, working with a significant value ($p < 0.05$), the research did not find a significant association between pes planus and age, gender, or BMI.

Conclusion: The findings underscore the utilization of the plantar arch index (PAI) in assessing foot characteristics and determining the prevalence of Pes Planus among adolescents. The significant number of adolescents with pes planus (37%) shows there is need to sensitize the populace on foot pain and its possible causes. The conventional belief that pes planus can be linked to BMI and gender has also been clarified.

Keywords: Flat-foot; Foot-pain; Prevalence; Adolescent; Plantar-arch-index

Introduction

The adolescence phase represents a critical juncture in an individual's life, bridging the transition from childhood to adulthood and exerting a substantial influence on overall health. Within this transformative period, spanning ages 10 to 19 [1], adolescents undergo significant changes in foot structure, marked by the development of medial longitudinal arches. Pes planus, also known as flat feet, emerges when the medial longitudinal arch of the foot is absent or reduced, impacting weight distribution, shock absorption, and overall foot biomechanics. Pes planus is

associated with foot pain, especially when walking or standing and discomfort, which makes the individual's active lifestyle altered. Moreover, it is crucial to consider that in typically developing children, normative data suggests that a 'flat' foot posture is considered normal up to the age of eight [2]. This phenomenon is attributed to age, appropriate osseous and ligamentous laxity, increased adipose tissue, and immature neuromuscular control. The 'flatness' observed in this foot posture is variable but tends to decrease over the initial decade of life [3-5]. However, in some cases, it could persist until and through the adolescent stages of

life, which could in turn, cause musculoskeletal issues and knee pain, back pain, postural instability, The significance of assessing the Plantar Arch Index (PAI) arises from its role in identifying and evaluating pes planus. PAI offers a quantitative measure of arch height, facilitating the classification of individuals into distinct arch categories. This objective evaluation eliminates subjectivity, enhancing diagnostic accuracy. The use of PAI helps to differentiate between normal arches and pes planus, reducing misdiagnosis and ensuring appropriate interventions.

Prior research has indicated that the foot arch index is subject to influence by several factors, encompassing age, gender, body mass index, and physical activity level [6]. This suggests that these variables play a significant role in shaping and determining the characteristics of the foot arch index, emphasizing the need to consider multiple factors when assessing and interpreting this parameter in the broader context of foot health and biomechanics. The assessment of foot structure serves as a crucial initial step in any early treatment, underscoring its significance. Existing literature presents conflicting perspectives on the optimal timing for prognosis and intervention in Pediatric flatfoot [7-9]. However, a consensus prevails that a diminished Medial Longitudinal Arch (MLA) height in children under six years is generally considered non-critical [10].

Given the dynamic nature of foot development, especially during the critical adolescence phase, understanding the changes of the foot arch index becomes paramount. The Plantar Arch Index (PAI) serves as a valuable tool in this context, offering a standardized and objective method for evaluating foot arch characteristics. By comprehensively assessing PAI, healthcare professionals, clinicians, and researchers can gain insights into the prevalence of pes planus, identify individuals at risk of related foot problems, and tailor effective interventions. PAI not only aids in accurate diagnosis but also facilitates the development of targeted treatment plans, ultimately contributing to the promotion of optimal foot health and overall well-being in the adolescent population and beyond.

The study is aimed to contribute valuable insights into the prevalence rates, distinctive features, and factors associated with pes planus among adolescents. Adolescent-hood was chosen because it is when flat foot manifest better (pes planus cannot correct naturally without intervention after adolescent-hood). This deeper understanding of the topic can shed more light on the prevalence rate of pes planus among the population, preventive strategies, sensitize the populace of the need for early diagnosis and management, hence, improve foot health outcomes for adolescents in Nigeria and beyond.

Materials and Methods

Study design and setting

This study, conducted between January 2023 and August 2023, employed a cross-sectional study design to evaluate the

plantar arch index (PAI) and determine the prevalence of pes planus among adolescents in Owerri, Nigeria. A sample of 160 participants (78 Males and 82 Females) selected using stratified random sampling technique participated in the study.

Data collection

In the process of gathering data, a detailed and carefully executed approach was employed, particularly in the measurement of the Plantar Arch Index (PAI) using the ink method. The ink method, a fundamental aspect of data collection, involved a systematic procedure to capture accurate footprints. Participants were instructed to place their feet on a surface containing stamp ink, ensuring an even distribution of the ink with a roller brush. This step created distinct footprints on plain white A4 paper, offering a tangible representation of each participant's foot structure. Following the acquisition of footprints, the feet underwent a thorough cleansing process with soap and water, followed by a meticulous cleaning with acetone. This ensured the removal of any residual ink and maintained the hygiene of the participants' feet.

Data analysis

The subsequent calculation of the Plantar Arch Index (PAI) adhered to *Staheli* Method of Arch Index calculation. The *Staheli* method involves drawing tangent lines at the medial forefoot edge and heel region [11]. The mean point of these lines is calculated, and from this point, perpendicular lines are drawn, crossing the footprint. The procedure is repeated for the heel tangency point, resulting in the measurement of the support width of the central region to the foot (A) and of the heel region (B).

The plantar arch index (PAI) is obtained by dividing the A value by B value:

$$PAI = \frac{A}{B}$$

Where;

PAI = *Plantar Arch Index*

A= *support width of the central region to the foot*

B= *support width of the heel region*

This systematic process provides a quantitative representation of the foot arch characteristics, ensuring a comprehensive assessment through precise measurements and calculated ratios. A perpendicular line was then drawn, intersecting the footprint from the medial forefoot. This procedure was replicated for the heel region, creating a comprehensive visual representation of each participant's footprint.

The arch was classified based on the calculated PAI values into distinct categories:

Low arch (0.9–1.2), Normal arch (0.5–0.9), High arch (0.2–0.5), and Cavus (<0.2) [11,12].

The IBM SPSS Statistics version 24 was used for data analysis in this study. Descriptive statistics, encompassing mean, standard deviation, and frequency distributions, summarized key characteristics of the study participants. The t-tests were used to assess potential differences in PAI values between subgroups. Multiple regression analysis was used to examine relationships between PAI and various demographic and health-related factors, including age, gender, and BMI. This comprehensive approach identified potential predictors of PAI. The statistical significance level (α) was set at 0.05 ($p < 0.05$).

Ethical consideration

Ethical approval for this study was obtained from the Research Ethics Committee of the Department of Prosthetics and Orthotics at the Federal University of Technology, Owerri. The approval process ensured adherence to ethical guidelines. Informed consent was obtained from both participants and their legal guardians before data collection, underscoring the voluntary

nature of participation and the confidentiality of personal information. Participants retained the right to withdraw from the study at any time without facing any negative consequences.

Results

The analysis of demographic characteristics unveiled a diverse composition among the adolescent participants. In terms of age, the study encompassed individuals ranging from 10 to 19 years old. The distribution across age groups as shown in Table 1 is detailed as follows: 10 years (13.75%), 11 years (10%), 12 years (6.88%), 13 years (18.13%), 14 years (8.75%), 15 years (9.37%), 16 years (10%), 17 years (6.87%), 18 years (8.75%), and 19 years (7.5%). Regarding gender, the study maintained a balanced representation, with 48.75% males and 51.25% females. BMI classifications further enriched the demographic analysis, revealing that 33.75% of adolescents were underweight, 45.63% maintained a healthy weight, and 20.62% were classified as overweight.

Table 1: Demographic Characteristics of Participants.

Age Group	Frequency	Percentage
10-12	49	30.63%
13-14	43	26.88%
15-16	31	19.38%
17-19	37	23.13%
Total	160	100.00%
Gender	Frequency	Percentage
Male	78	48.75%
Female	82	51.25%
Total	160	100.00%
BMI Category	Frequency	Percentage
Underweight	54	33.75%
Healthy	73	45.63%
Overweight	33	20.62%
Total	160	100.00%

On the prevalence of Pes Planus among adolescents, the data showed that out of the 160 participants, 37.5% exhibited Pes Planus deformity, while the majority, accounting for 62.5%, fell

into other arch classifications such as high arch or normal arch as shown in table 2.

Table 2: Prevalence of different arch types among the participants.

PAI Classification	Frequency	Percentage
Normal arch	81	50.60%
Low arch/pes lanus	60	37.50%
High arch	19	11.90%
Total	160	100.00%

Source: field survey, 2024.

Table 3 presents an Omnibus Test of Model Coefficients examining the association between Age, Gender, and the prevalence of Pes Planus. The test resulted in a Chi-square value of 6.665, at 0.036 significance value. This indicates that there is no significant association between age, gender, and the prevalence of Pes Planus among the participants.

Table 3: Omnibus Test of Model Coefficients between Age, Gender, and Pes Planus.

	Chi-square	Df	Sig.
Step 1	6.665	2	0.036
Block	6.665	2	0.036
Model	6.665	2	0.036

Table 4.1: Model Summary between Age, Gender, and the Prevalence of Pes Planus.

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	105.882a	0.041	0.081

Table 4.2: Variables in the Equation.

Variables in the Equation	B	S.E.	Wald	Df	Sig.	Exp(B)
N Gender (1)	0	1	0.235	0	1	-
Age	0.519	0.014	0.096	6.028	1	1.265
Constant	0	1	-5.538	1.49	13.819	1

The result shows a model summary between age, gender, and the prevalence of Pes Planus. A logistic regression model was performed to see whether the age and gender of adolescents would predict their odds of having flat feet. The overall model was found to be statistically significant ($X^2(2) = 6.6665, p < 0.05$), with a Nagelkerke R2 value of 0.81. Only age ($X^2(1) = 0.519, p = 0.014$) was found to be statistically significant in predicting the odds of adolescents having flat feet.

From tables 4.1 and 4.2, Taking a closer observation of the influencing factors, Gender ($B = 0.000, p = 1.000$) and age ($B = 0.235, p = 0.014$) are not statistically significant factors determining the prevalence of Pes Planus because they are way

higher than the significant value of 0.05. Therefore, there is no association between age, gender, and the prevalence of Pes Planus among adolescents in Owerri.

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

The Chi-Square test is shown in Table 5. explains the Pearson Chi-Square value of 89.89 and the Asymptotic significance value of 0.656. According to the standard significant value of 0.05, the significance value of 0.656 is greater, therefore there is no statistically significant association between BMI and Pes Planus. These findings underscore the complexity of demographic factors influencing foot conditions in the adolescent population of Owerri.

Table 5: Chi-Square Tests for association between BMI and the Prevalence of Pes Planus.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	89.89	96	0.656
Likelihood Ratio	72.685	96	0.964
Linear-by-Linear Assoc.	2.116	1	0.146
N of Valid Cases	160		

Discussion

In this study, we investigated the prevalence of pes planus among adolescents in Owerri, using plantar arch index as a parameter for assessing the foot. The observed prevalence of Pes Planus among adolescents in Owerri (37.5%) suggests that flat feet significantly exist among this population. Also, some of the participants had foot pain without knowing the cause and possible solutions prior to participation in the study. With their participation in the study, they have been enlightened on pes planus, in terms of its symptoms, causes, assessment and management. The study also tried to determine if factors like gender, body mass index (BMI) have any link to pes planus, as believed in the local setting where the research was conducted. It was observed that there were no significant associations between gender, BMI and Pes Planus, which challenges conventional assumptions about the risk factors for flat feet. In our context, where cultural and lifestyle factors play a significant role, these findings prompt a reconsideration of existing paradigms. It underscores the importance of contextualizing research outcomes within the unique sociodemographic landscape of Nigeria. Also, the choice of footprint/PAI as an evaluation approach of the foot condition has sparked debates in the literature. While some consider it a poor evaluation method, numerous authors, including Gervis, Engel, Viladot, Cavanagh and Rodgers, and Staheli et al., amongst others, advocate for its use [13 -18]. This study has also revalidated the use of footprints to assess foot conditions, as it used the method to achieve its aim and result.

Conclusion

We found that pes planus was significantly prevalent among the adolescents in Owerri, Imo State, and many of the participants never had knowledge of it prior to the study. The study also observed that age, gender and BMI have no link to pes planus. The findings emphasize the importance of foot health sensitization among adolescents, which is the stage pes planus becomes evident. As we navigate healthcare practices in our Nigerian society, these insights can guide towards the development of targeted interventions and educational initiatives, which will ultimately promote better foot health outcomes for our adolescents. The research underscores the Plantar arch index's importance in identifying Pes Planus deformity, highlighting the significance of this condition among Owerri adolescent population. Analysis of the plantar arch index revealed the significance of this metric, emphasizing its utilization in assessing foot characteristics. The study debunked prevailing assumptions, showing no significant associations between age, gender, BMI, and pes planus prevalence among adolescents in Owerri.

Conflict of Interest

No Conflict of interest relevant to this article declared.

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