Research Article

Prevalence of Pes Planus and Associated Risk Factors Among School-Going Children Aged 7–14 Years in Chennai, Tamil Nadu

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Abstract

Background: Flat foot (pes planus) is a common developmental variation in children and adolescents, typically considered a physiological condition that changes with growth and lifestyle factors. It is significant to gain knowledge of its prevalence and related predictors to be able to differentiate between normal developmental patterns and those that have to be dealt with by some sort of intervention especially when dealing with school-aged populations.

Objectives: To determine the prevalence of flat foot and the correlation of this condition with age, gender, physical activities and anthropometric measurement among school going children between the ages of 7-14 years in Chennai, Tamil Nadu.

Methods: This was a cross-sectional study conducted among 232 children selected using purposive sampling from a higher secondary school in Chennai.The feet status were measured in the footprint method and arch index computed to categorize the states of the feet arch. The physical activity, body mass index (BMI), weight, height, and gender collected on age using a structured proforma. Statistical software SPSS was used to do the statistical analysis with methods of chi-square and independent Student t-test at the level of $p < 0.05$.

Results: Its general prevalence was 27.6%. The prevalence was much higher among children aged 7-10 years (34.2%) than during the age of 11-14 years (15%) ($p = 0.002$). Flat foot occurred much more frequently in physically inactive children (39.1%) than in physically active children (16.2% $p < 0.001$). Flat foot was not significantly related to gender, BMI, height, and weight ($p > 0.05$).

Conclusion: Flat foot is still a widespread occurrence in a physically inactive school-going children especially the younger. There seems to be a significant role of age and physical activity, but no significant role is determined by gender and anthropmetric measures. Healthy medial longitudinal arch development can be promoted through physical activity in the childhood period.

Keywords (MeSH terms): Pes planus, foot deformities, school children, physical activity, body mass index, foot arch, cross-section studies, India.

Introduction

Pes planus is a condition characterised by a reduction or absence of the medial longitudinal arch during weight-bearing. The medial longitudinal arch is important in shock absorption, transmission of loads as well as efficient gait mechanics. Arch developmental changes throughout growth may be physiological, but persistent flat foot can be a long time changes biomechanical functions of lower limbs and has been linked with pain, fatigue, and functional impairment in later adulthood [1].

The medial longitudinal arch is an active process that goes on during the childhood and early adolescence. Ligamentous laxity, increased in plantar adipose tissue and a lack of total neuromuscular regulation were often involved in early age and led to the emergence of an arch flattening. In the course of skeletal maturation, those factors decrease and, consequently, cause a progressive increase and stabilization of the arch [2]. Footprint analysis longitudinal and cross-sectional studies have consistently shown a decreasing pattern of flat foot with age, and it is also believed that flat foot in young children is just a developmental change and not a pathology [3,4].

Epidemiological research studies undertaken in different populations have shown a broad range of fluctuations on the prevalence rates of pediatric flat foot between about 10% and beyond 40 per cent based on the age group, classification of diagnosis and the mode of assessment [1,3,5]. Some of the factors have been investigated with regards to their application in the association of flat foot such as age, gender, body mass index (BMI) and some lifestyle aspects. Although age has always proved to be one of the key determinants, there are inconclusive results on the differences in gender. Other studies have documented that higher prevalence rate is found in males although

other studies have reported no significant gender based difference in prevalence rate [6,7].
There have also been studies on body mass index which is thought to be a contributing factor to flat foot because of the expanded mechanical loading on the developing foot. Nonetheless, findings are not consistent. Garcia-Rodriguez et al. noted that in children, flexible flat-foot was not available to be correlated with an increase in body torment, and the structure maturation process might be a dominating factor compared to body mass on its own [8]. On the contrary, other population based research reports indicated that the prevalence of flat foot among the overweight children had been higher at the older ages, thus BMI is not acting independently but in a combined effect with developmental factors [9].
Factors that are lifestyle-related especially physical activity have become of growing importance in researches in pediatric foot. Consistent weight-bearing exercise is also suspected of improving intrinsic foot muscle strength, neuromuscular coordination, and control to promote the development of the medial longitudinal arch. Children with poor physical activity have been shown to have a high rate of flat foot in school, indicating the possible preventive role of physical activity in childhood [10,11]. These conclusions are particularly applicable in a scenario where school going children are becoming more and more sedentary.
Biomechanical studies also contribute to the stability of the arch using functional loading. It was experimentally proved that medial longitudinal arch structure is supported by ligamentous integrity and muscular support during weight bearing and thus the significance of the normal functional use of the foot during growth was established [12,13].
In Indian region, the pediatric paths of flat foot are unavailable, especially South India. Footwear behavior, physical activity behavior and changes in environmental exposure can also affect foot morphology, and thus, region sensitive epidemiological data is essential. The bulk of the available researches on the Indian has been limited to specific geographic areas, and there is still a gap in the understanding of the prevalence of flat foot and its underlying factors among children in South Indian schools.
Considering these, this research was done to determine the prevalence of flat foot in school going children aged between 7-14 years in Chennai, Tamil Nadu and discuss the association between age, gender, physical activity and anthropometric parameters based on an objective footprint based archive index methodology.

Materials and Methods

The study was a school-based cross-sectional study on children of 7-14 years, studying their matriculation higher secondary school, Chromepet, Chennai, Tamil Nadu. Data collection was only done with the permission of the school authorities and the ethical approval of the Institutional Ethics Committee was given. Informed consent was obtained in writing by the parents or legal guardians of all the participating children before the staff was recruited.
The children in the age range that were relatively present at the time of the data collection and the parents of these children gave consent took part in the study. Purposive sampling has been used. Children with known congenital cases of foot deformities, neuromuscular disorders, a history of surgery of the lower limbs, or those who sustained injuries to the lower limbs were not part of the sample to reduce confounding during the assessment of the foot position.
The size of the sample was determined with a projected prevalence of 30 percent of the flat feet. The research study on flexible flat foot in primary school children determined that the prevalence rate of using footprint-based assessment showed differences with the prevalence of flexible flat foot standing at 0.30 [6]. The sample size was calculated using the formula formula $n=Z^2\ pq/d^2$, with a confidence level of 95($Z= 1.96$), $p=0.30$, $q=0.70$ and the absolute degree of precision is 6%, determined the minimum sample size as 224. A 5% adjustment was made to correct the potential non-response and missing measurements and a resultant sample size of 232 children was obtained and these children were included in the final analysis.
The age and gender sociodemographic information were gathered with the help of a proforma. Measures Boeing height were taken to the nearest 0.1cm with a stadiometer and weight to the nearest 0.1kg with a calibrated digital weighing scale. BMI was calculated as weight (kg) divided by height squared (m^2).
Foot standing position was measured by footprint technique which is an effective and acceptable method of measuring the medial longitudinal arch in a pediatric population as well as being a non-invasive method of analyzing foot position [2,3]. Footprints had been made by ink method wherein the respondents had been positioned in a relaxed weight bearing position with their feet unshod. Arch index (AI) was determined by finding the area of the midfoot divided by the total area of the foot without including the toes. The subjects were classified as either flat

foot or normal arch based on the set arch index threshold.
Physical activity was assessed based on frequency and duration of outdoor activities per week and categorized as active/inactive and established as either physically active or physically inactive by means of frequent involvement in outdoor physical leisure or sports.
The results were put into the SPSS software to analyze. The characteristics of the participants were summarized with descriptive statistics. The chi-square test was used in assessing the associations between the flat foot and categorical variables where the difference in the continuous variables were evaluated using the independent Student t-test. The p-value of less than 0.05 was deemed as statistically significant.

Results:

Table 1. Baseline Characteristics of the Study Participants (n = 232)

Variable	n	Mean ± SD
Height (cm)	232	134.56 ± 13.32
Weight (kg)	232	32.47 ± 13.25
Body Mass Index (kg/m²)	232	17.31 ± 4.14
Left Arch Index	232	0.206 ± 0.064
Right Arch Index	232	0.205 ± 0.061

The factors of anthropometric parameters in the population of the study showed a medium dispersion of a heterogeneous group of the school-going children who were between the age group 7-14 years. The BMI of 17.31 kg/m ^{2} means that majority of participants were in the normal or underweight age bracket. The fact that left (0.206) and right (0.205) values of the arch index are close implies that there is equal development of the medial longitudinal arches in both parts of the cohort.

Table 2. Prevalence of Flat Foot Among Study Participants (n = 232)

Foot Arch Status	Frequency (n)	Percentage (%)
Normal Arch	168	72.4
Flat Foot	64	27.6

Flat foot was observed in 27.6% of participants by assessing their arch indexes with the rest (72.4) displaying normal arch morphology. This means that flat foot is still a relatively frequent observation in this population of children in the school going age.

Table 3. Association Between Sociodemographic and Lifestyle Factors and Flat Foot (n = 232)

Variable	Category	Flat Foot n (%)	Normal Arch n (%)	χ^2	p-value
Age Group (years)	7–10 (n = 152)	52 (34.2)	100 (65.8)	9.683	**0.002**
	11–14 (n = 80)	12 (15.0)	68 (85.0)		
Gender	Male (n = 130)	33 (25.4)	97 (74.6)	0.717	0.397
	Female (n = 102)	31 (30.4)	71 (69.6)		
Physical Activity	Yes (n = 117)	19 (16.2)	98 (83.8)	15.213	**<0.001**
	No (n = 115)	45 (39.1)	70 (60.9)		

An age effect has been clearly present, where younger children (7-10 years) were much more prevalent in having flat foot (34.2) than the younger children (11-14 years old) (15; p = 0.002). Flat foot was significantly associated with physical inactivity because close to a quarter of inactive children (39.1) had flat foot with respect to (16.2) of physically active children (p < 0.001). The gender did not show a statistically significant relationship with the prevalence of the same being similar among males and females.

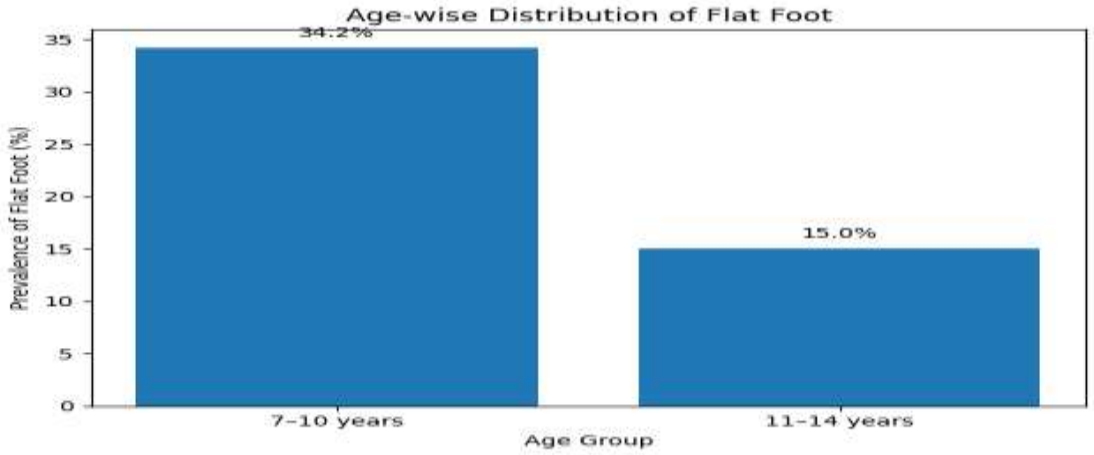
Table 4. Comparison of Anthropometric and Foot Arch Parameters by Flat Foot Status

Parameter	Flat Foot (n = 64) Mean ± SD	Normal Arch (n = 168) Mean ± SD	Test Value	p-value
Body Mass Index	17.35 ± 4.18	17.29 ± 4.14	t = 0.920	0.359

(kg/m²)				
Height (cm)	135.06 ± 11.91	134.13 ± 13.63	t = 0.632	0.528
Weight (kg)	32.64 ± 12.52	32.41 ± 13.55	t = 0.907	0.365
Left Arch Index	0.211 ± 0.065	0.204 ± 0.063	—	NS
Right Arch Index	0.210 ± 0.061	0.201 ± 0.061	—	NS

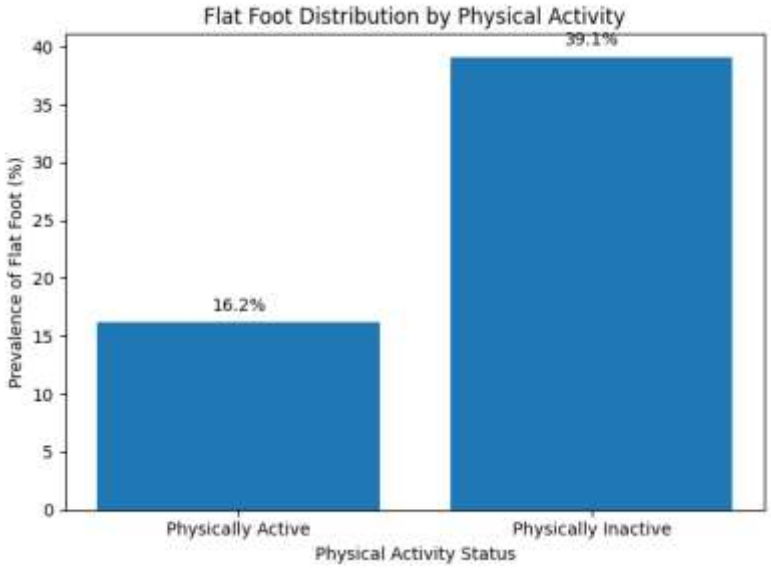
No significant differences between the measured variables of BMI, height and weight between individuals with and without flat foot were obtained thus there were no significant general anthropometric measures that affected flat foot occurrence in this cohort. Likewise, there were very small differences in left and right arch index values between groups, which supports the idea that other factors than the body size, including, but not limited to, age and physical activity, are more significant in the development of the medial longitudinal arch.

Figure 1. Age-wise Distribution of Flat Foot Among School-going Children (7–14 Years)



An age-related decline in flat foot prevalence was observed. Prevalence was significantly elevated in children between **7-**10 years of age (34.2%) than in children between 11-14 years of age with only 15% of children having flat foot. Such an observable age-progressive attenuation is indicative of progressive maturation of the medial longitudinal arch with age.

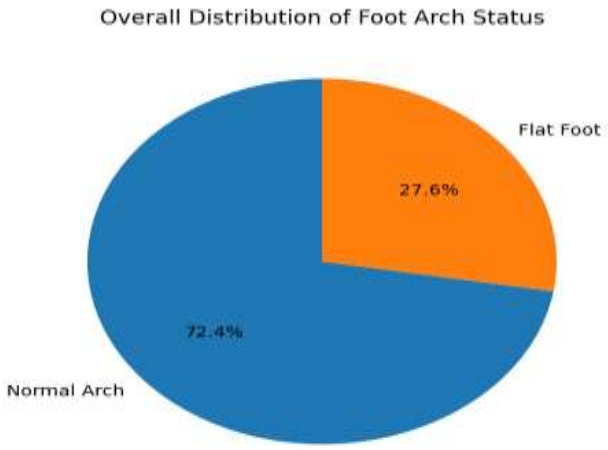
Figure 2. Distribution of Flat Foot According to Physical Activity Status



There is a clearly defined difference in prevalence of flat feet in active and inactive children. In children with

regular physical activity, flat foot was found in 16.2, where a considerably large percentage (39.1) was observed in physically inactive participants. The figure
brings out the protective relationship of regular exercising on the normal development of the arch.

Figure 3. Overall Distribution of Foot Arch Status Among Study Participants



This statistic gives a summary of the structure of the feet arches in the research sample. Most of the children (72.4) had normal arch
development with 27.6% being classified as having flat foot. The distribution emphasizes the fact that flat foot is a significant
percentage of the pattern of foot posture among school aged children in this cohort.

Discussion

The current research compared the prevalence rate of flat foot and its determinants among the 7-14 years school going children of Chennai, Tamil Nadu. The prevalence in general was noted to be 27.6 and thus it was observed that flat foot is very common among members of this age bracket. This analysis showed an important correlation with age and physical activity and no statistically significant relationships with flat foot among gender, body mass index (BMI), height, and weight.

An age-related decline suggests progressive maturation of the medial longitudinal arch, where children between the age of 7-10 years had higher prevalence rate as opposed to 11-14 years old. This result is in line with previous research which outlines the medial longitudinal arch development as a progressive process that proceeds into childhood. According to Pfeiffer et al. the prevalence of flat foot was much more pronounced in children younger and it should be pointed out that the cases of flat foot are not necessarily a pathology but just a developmental stage of the child [1]. The same age related patterns have been also shown by the use of footprint based systems with Chen et al declaining the overall prevalence of flat foot as children age [3]. The results validate the idea that the arch maturation is closely associated with the development of the skeletons and neuromuscular [2].

In the current study, the prevalence of flat foot was not significantly correlated with gender, whereby there was no difference in the prevalence of flat foot in both boys and girls. The observation is consistent with the results obtained by El O et al. who have observed that there were no statistically significant differences between the primary school children in terms of gender prevalence of flat foot [6]. Similar findings were also manifested in one large school-based study carried out in Taiwan where the gender was not a factor by itself in the determination of flexible flat foot in the study after factoring in the age among other factors [7]. The similarity in gender differences in the studies is indication that the variation of sex in the prevalence of flat foot could be more as a result of behavior or environmental factors than differences in nature.

Among the most remarkable discoveries of the current research was the high level of correlation between flat foot and physical inactivity. Flat foot prevalence was significantly higher among physically inactive children. This has also been found to have similar associations in several population-based studies. Ezema et al. showed that low physical

activity levels had significant relationships with flat foot in primary school children [10]. Birhanu et al. have also expressed similar results more recently, stating that children who were less physically active were at more risk of getting flat foot [11]. Regular engagement in weight-bearing physical exercises could potentially increase the inherent muscle strength of the foot, neuromuscular coordination, and even boost the stability of the arches, thus aid the normal growth of feet.

However, the present study did not demonstrate significant BMI in relation to flat foot. Body mass alone was not a major determiner of the morphology of the arch as children with flat foot and those without had similar BMI values. This observation is complementary to the observation of Garcia-Rodriguez at al. who stated that flexible flat foot among children did not necessarily correlate with the weight gain in the body [8]. Other studies however have indicated contradictive outcomes. When Villarroya et al. found that flat feet were more prevalent in overweight and obese children, especially in younger ages, it had been suggested that the body mass index was not a risk factor and it increased the risk because of the other developmental factors [9]. These differences set out to show that the association between BMI and flat foot is complex and could vary using the age, physical activity and neuromuscular maturation.

Biomechanically, the results of the current study highlight the role of supportive mechanisms of functional and structural nature in the integrity of medial longitudinal arch. The importance of ligament structures and muscular support in stability of the aches in weight bearing has been proven by experimental studies. According to Huang et al., intrinsic and extrinsic foot muscles play a role in supporting the longitudinal arch by emphasizing on the need to load the muscles in a functional manner during the process of growth [12]. Such biomechanical considers the current observation that activity-associated factors could be more determinant than the inactive anthropometric measures.

Pediatric data on flat foot in regions is also limited in India especially in South India. The findings are consistent with prevalence rates reported in similar settings in other developing regions and highlights the necessity of local epidemiological evidence. There are studies that have been done in Indian school populations that have given different rates of prevalence probably because of the difference in age distribution, assessment techniques and lifestyle trends. Creation of region-specific data is crucial in order to make informed health screening programs and preventive measures applied in schools specific to local communities.

The advantages associated with the research are its school-based design, objective measurement of foot posture through the use of arch index as well as measurement of various possible determinants. Nevertheless, the study is cross-sectional, which narrows down the possibilities of causal inference, and coverage of children in one school may not be generalizable. Larger and more diverse populations in longitudinal studies are justified to shed more light on the natural history of the development of flat feet.

Conclusion

Flat foot is one of the findings common among school going children whose age ranges between 7-14 years and also found to be common in younger ages. The current investigation illustrates that there is a definite reduction in the prevalence of flat foot as the age increases indicating the natural maturation of the medial longitudinal arch in childhood. Physical inactivity was identified as a significant modifiable factor associated with flat foot, and that regular weight-bearing activities were relevant in the healthy development of one foot. However, this was not the case when it comes to gender parameters, anthropometric body parameters including body mass index, height and weight. These findings highlight the importance of school-based screening and promotion of physical activity to support healthy foot development. The screening programs in schools and active lifestyles can be used to facilitate the ideal musculoskeletal progress, as well as assist in timely recognition of children who need further examination.

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