

Lecture Notes in Electrical Engineering 1087

Ruchika Malhotra · L. Sumalatha ·
S. M. Warusia Yassin · Ripon Patgiri ·
Naresh Babu Muppalaneni *Editors*

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Former Vice-Chancellor, JNTU Kakinada



Late Prof. Ch. Satyanarayana
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Foreword

The 3rd International Conference on Computer Vision, High Performance Computing, Smart Devices and Networks (CHSN-2022) is aimed to bring researchers together working in this area to share their knowledge and experience. In this conference, topics of contemporary interested would be discussed to provide a holistic vision on latest technologies for computer science and engineering. The scope includes data science, machine learning, computer vision, deep learning, artificial intelligence, artificial neural networks, mobile applications development and Internet of Things; conference participants are expected to gain relevant knowledge and better understanding of the applications of computer science in various fields.

CHSN-2022 would be both stimulating and informative with the active participation of galaxy of keynote speakers. We would like to thank all the authors who submitted the papers, because of which the conference became a story of success. We also would like to express our gratitude to the reviewers, for their contributions to enhance the quality of the papers. We are very grateful to the keynote speakers, reviewers, session chairs and committee members who selflessly contributed to the success of CHSN-2022. We are very thankful to Jawaharlal Nehru Technological University Kakinada, Kakinada, for providing the basic requirements to host the CHSN-2022.

Last but not least, we are thankful for the enormous support of publishing partner, i.e., Springer, for supporting us in every step of our journey toward success.

Kakinada, India

Prof. A. S. N. Chakravarthy
Convener, CHSN-2022

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Analysis of Prevalence of Flat Foot in Primary School Children



Subodh Mor, Shikha N. Khera, and G. C. Maheshwari

Abstract Flat foot is a common health condition that prevails among children as well as adults. This paper analyses the relationship between age and gender with the prevalence of flat feet among primary school children. The results are validated on 424 primary school children (254 males and 170 females) between the age of 6 years to 10 years in Delhi, India. The foot imprinter plate as well as physical and photographic assessment was used to diagnose the presence of flat feet among primary school children. The number of children diagnosed with completely flat feet was 118, and children diagnosed with partial flat feet were 176. The results show out of every five children, three children were either completely or partially flat feet (69.3%). The results showed that there was a significant association between gender and flat foot. It was concluded that assessment of flat feet should be made available to children and parents at an early age to prevent the condition to be converted into a serious health problem and hindrance in various sports activities.

Keywords Flat feet · Partial flat feet · Primary school children · Sports activities

1 Introduction

The feet are an important factor in an individual's health since it plays a key role in mobility and posture and is responsible for the well-being and quality of life of an individual. Flat feet, also known as pes planus, is a common biomechanical problem faced by many individuals from an early age. It is present in infants as a part of the development of the foot and is gradually 15–20% resolved in adulthood [9, 21].

Flat feet can be defined as a postural deformity in which the foot does not have a normal arch where the entire sole of the foot is in near or complete contact with the ground [17]. These foot deformities may cause the development of various issues such as pain, fatigue, imbalance, and uneven distribution of planer pressure [16] and also

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be a cause of various injuries. These changes can subsequently lead to compromise in well-being and quality of life while affecting the mobility, walking speed, and stance duration of an individual [12]. Flat feet can be divided into two categories, namely flexible (partial) or rigid. Flat feet can occur due to family history, structural and musculoskeletal abnormalities, neuromuscular issues, obesity, and urban lifestyle [1, 5, 6].

Flat feet may lead to hindrances in various sports activities like running, jumping, hopping, and various other coordination activities as excessive foot pressure can lead to stress on the legs, hips, and spine [4]. It can also be a cause of various injuries in sports persons. In previous studies, it was also found that anterior knee pain was high in male young defense recruits as compared to females. It was also shown that there was a significant correlation between flat feet and anterior knee pain [15].

There have been various studies that evaluate the relationship between personal characteristics such as age, gender, and BMI with flat feet [2, 3, 7, 10, 11, 13, 18, 23]. In this work, we analyze the relationship between age, gender with flat feet. The results are validated on 424 primary school children in Delhi, India, between 6 years and 10 years of age group. The data has been collected as a part of an awareness and educational campaign in schools. The early detection of flat feet can prevent the issue from converting into a serious medical condition among children. It will also guide parents and children in the selection of appropriate sports as a future career.

The rest of the paper is organized as follows: Section 2 presents the related work, and the research background is summarized in Sect. 3. In Sect. 4, results are presented and discussed. Section 5 presents the conclusions of the work.

2 Related Work

In this section, the studies that are closely related to our work are summarized. Table 1 presents the summary of the size of participants, age, research variables, and statistical tests used in the studies. Eluwa et al. examined 1000 students of Akwa Ibom State aged between 20 and 30 and concluded that there were a higher number of females with flat feet as compared to males [10]. Chang et al. analyzed 2083 school children and concluded that males had twice more flat feet as compared to females. Further, overweight children had more flat feet as compared to the ones with normal weight [7]. Ezema et al. conducted a study with 474 primary school children [11]. They found that there was a significant association between flat feet and age and also between obesity and flat feet. In [11], it was further concluded that males were twice likely to be diagnosed with flat feet than females. Pashmdarfard et al. assessed the prevalence of flat feet among 1700 primary school children aged between 7 and 12 years [18]. There was a significant relationship found between weight and flat feet. Bhoir et al. conducted a study with students aged between 18 and 25 years and found that there was no correlation between gender and BMI with arch index [3]. Al-shenqiti et al. examined school children between 6 to 12 years and concluded

Table 1 Summary of related work

Authors	Study size	Age	Variables used	Statistical techniques
Eluwa et al. [10]	1000	20–30	Gender	Mean and standard deviation
Chang et al. [7]	2083	7–12	Age, gender, and BMI	Multivariate analysis
Ezema et al. [11]	474	6–10	Age, gender, and BMI	Chi-square test
Pashmdarfard et al. [18]	1700	7–12	Age, height, weight	Ordinal regression
Bhoir et al. [3]	80	18–25	Gender and BMI	Correlation analysis
Al-Shenqiti et al. [2]	563	6–12	Age, weight, height, and BMI	Correlation analysis

that there was no correlation between weight and BMI with flat feet, and there was a significant correlation between age, height, and gender with flat feet [2].

In this work, data from 424 primary school children in Delhi, India, is collected, and the association between age, gender, and prevalence of flat feet and partial flat feet is assessed.

3 Research Methods

In this section, the description of variables, study participants, and statistical techniques is presented.

3.1 Research Design and Variables

The study compiled a list of all primary school children between 6 and 10 years. The data for the children with completely flat feet or low arc (partial flat feet) was collected. Physical assessment, as well as discussions, was carried out so that the children with other foot deformities such as high arc or other deformities could be excluded from the study.

The flat foot issues that are of little concern at an early stage of children's upbringing may become a serious issue at a later stage when the child becomes older particularly if it is associated with mobility and quality of life issues. Further, this information can be used effectively by the children and their parents for the pursuance of sports now and in the future.

The children were first physically examined. Then, photographic analysis was obtained for further assessment (Fig. 1). A foot imprinter plate was used to analyze whether the foot was flat, partially flat (low arched), or normal. The portable foot



Fig. 1 Foot assessment

imprinter plate had 2704 calibrated sensors, 5 Hz frequency, 5% accuracy, 100% digital calibration, and -10 to $+45$ °C temperature. Simultaneously, a check on weight distribution on both feet was made. Finally, the obtained data was analyzed by an expert team, and based on the analysis, a recommendation folder consisting of suggested exercises and further details was given to the participant child.

3.2 Study Participants and Flat Foot Diagnosis

A total of 424 primary school children with age between 6 years and 10 years were included in the study. The data was collected from five classes (I-V). Ethical permission was obtained for the inclusion of the data. The parents were fully informed about the assessment procedure. The main aim of the assessment of primary school children was to educate children and their parents and to communicate basic information about his/her feet so that they have a better understanding of their children's needs, and better care can be provided to them. After the examination, the expert team summarized the characteristics of children including age, gender, and type of feet and prescribed appropriate exercises and measures that the child needs to learn and follow for improving the foot mechanics.

The study considered two personal characteristics, namely age, gender, and feet type with three categories (1) normal feet (2) partial flat feet, and (3) flat feet. Table 2 presents the summary of data from 424 participants with respective counts and percentages. There are 120, 82, 78, 68, and 76 primary school children aged 6, 7,

Table 2 Characteristics of participants

Variable	Value	Count (percentage)
Age	6	120 (28.3%)
	7	82 (19.3%)
	8	78 (18.39%)
	9	68 (16.03%)
	10	76 (17.92%)
Gender	Male	254 (60%)
	Female	170 (40%)
Feet type	Normal feet	130 (30.66%)
	Partial flat feet	176 (41.5%)
	Flat feet	118 (27.83%)

8, 9, and 10, respectively. The percentage of female children is 40% and male children 60%. There were 30.66% of children with normal feet, 41.5% of children with partial flat feet, and 27.83% of children with flat feet.

3.3 Statistical Analysis

In this work, chi-square, a statistical test, is used to find the association between the personal characteristics (age and gender) and the presence of flat feet or partial flat feet of a child. The chi-square test is a non-parametric test that is used to check whether there exists a significant difference between expected frequency and observed frequency [22]. In this test, data samples are drawn randomly from the population. This test works on categorical data or we can say that this test is used when the data is ordinal or nominal. The level of significance was 0.01. The hypothesis of the work is that there is an association between age, gender, and prevalence of flat feet or partial flat feet.

4 Analysis of Results

In this section, presented here is the analysis and discussion of the results of the statistical analysis carried out in this work. A total of 424 primary school children were included in the analysis. The association between age and gender with the prevalence of flat foot was analyzed using the chi-square test as given in Sect. 3.4.

4.1 Association of Personal Characteristics with Flat Foot

Table 3 presents the summary of the count of the presence of flat feet in school children with respect to age, between 6 and 10 years. The percentage of children with flat feet and partial flat feet at various age levels is depicted in the bar chart shown in Fig. 2. The prevalence of flat feet was found to be highest in 10-year-old children (36.84%) and lowest in 7-year-old children (21.95%). The prevalence of partial flat foot was found in about 43% of children aged 6, 7, 8, 10, and lowest in 9-year-old children (30.88%). There was no significant association found between age and flat foot at a 0.01 significance level (chi-square statistic: 11.134, p-value: 0.194).

Table 4 presents the prevalence of flat feet in primary school children with respect to gender. Figure 3 depicts the percentage of males and females with normal, partial flat, and flat feet. There are 14% of females and 37% of females and males with flat feet. There are 52% of females and 34% of males with partially flat feet. The association between the gender and prevalence of flat foot is found to be significant (chi-square statistics: 27.974, p-value: 0.000) at a 0.01 significance level.

Table 5 shows the prevalence of flat feet among male and female primary school children with respect to various levels of age. It can be seen flat feet are highest in 6-year-old and 10-year-old male children.

Table 3 Prevalence of flat feet with respect to age

	6 years	7 years	8 years	9 years	10 years
Normal feet	35	28	26	26	15
Partial flat feet	52	36	34	21	33
Flat feet	33	18	18	21	28

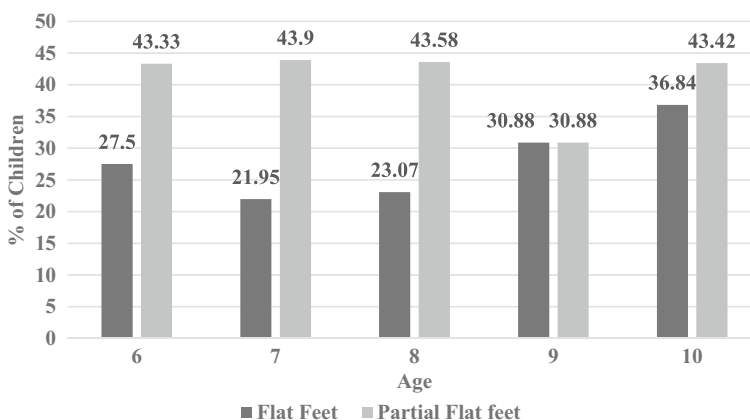


Fig. 2 Percentage of primary school children with flat and partial flat foot

Table 4 Prevalence of flat foot with respect to gender

	Male	Female
Normal feet	73	57
Partial flat feet	87	89
Flat feet	94	24

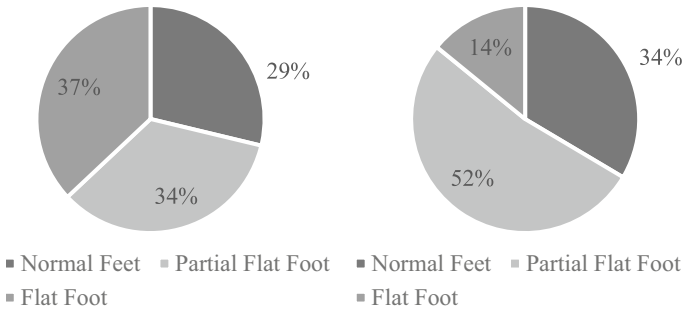


Fig. 3 Percentage of **a** males **b** females with normal, partial flat, and flat foot

Table 5 Prevalence of flat foot with respect to age and gender

Age	6 years		7 years		8 years		9 years		10 years	
	M	F	M	F	M	F	M	F	M	F
Normal feet	16	19	19	9	12	14	18	8	8	7
Partial flat feet	26	26	13	23	15	19	14	7	19	14
Flat feet	24	9	16	2	16	2	16	5	22	6

4.2 Discussion

It can be seen that there were 21.95–36.84% of primary school children with flat feet. This implies that at least one in every five primary school children had a flat foot. There were 43% of primary school children with partial flat feet which means that more than two in every five primary school children have a partial flat foot. Thus, more than 60% of primary school children have either flat feet or partial flat feet. In other words, three in every five primary school children have either a flat foot or a partial flat foot.

The study reveals that with age flat foot increases and 10-year-old children have the highest number of flat feet. The presence of partial flat foot was consistent among all age children except 9-year-old children. This implies corrective actions and changes should be taken at an early age so that the children with partial flat feet do not develop complete flat feet with age. However, the results show that there is no significant association between age and the prevalence of flat foot or partial flat foot. Chang et al. [7] and Ezema et al. [11] observed that the prevalence of flat foot among

primary school children decreased with age. Thus, further study is required to prove this hypothesis.

The findings of this study demonstrate that male primary school children with flat feet were more than twice as compared to their female counterparts. But, the prevalence of partial flat feet in female children was equal as compared to male children which means that the number of female children with flat feet may increase with growing age. There was a significant association detected between gender and flat or partial flat feet among children. The results are consistent with the other studies. Ezema et al. examined 474 primary school children aged between 6 to 10 years and found that about twice male children with flat feet were more as compared to females [11]. Chang et al. also observed that there were twice more female children with flat feet as compared to male children [7]. Pashmdarfard et al. found that there was no significant effect of gender on the prevalence of flat foot among 7 to 12 years aged children [18]. In [10], the results show that the female occurrences of flat feet were more as compared to male children. This may be because the study examined 20–30 years old participants.

4.3 Recommendations

The results of this study show that there is 27.83% and 41.5% of primary school children aged between 6 and 10 years with flat feet and partial flat feet, respectively. Thus, 294 out of 424 (69.3%) primary school children have either flat foot or partial flat foot which is a matter of concern. The initial sign of a flat foot may become an issue of concern at a later age as the child will get older. It may lead to a serious health issue or may affect the quality of life of the child by affecting physical mobility (walking, running, and balance), causing pain and other complications [8, 19].

The results by Martin et al. showed the prevalence of flat feet led to a decrease in quality of life and an increase in disability and pain in the feet [12]. The results of the study conducted by López-López et al. of Spanish patients showed that individuals with foot pathologies had worse quality of life as compared with individuals with the normal foot. The study emphasized improving foot health.

Given the fact that footwork, speed, agility, and balance are key components of many sports (basketball, tennis, and running), the prevalence of flat feet among children may affect the career of a child in sports in the future [4]. A flat foot increases the stress and pressure on the inside of the foot and ankles. The presence of flat feet may increase the risk of injuries in athletes during training sessions and sports competitions [14]. When the physical activity increases and the overwork is done by an individual with a flat foot, it can result in foot pain, muscle spasms, calf fatigue, hip or back pain, and so on. This may hinder the sports activities of an individual and their performance in various sports. Many times, an individual is not aware of the presence of a flat foot until some issue arises while playing a particular sport. Sharma and Upadhyaya emphasized that a flat foot affects the running performance of an athlete due to a decrease in ankle muscle strength [20].

The solution for the flat foot is relatively simple at a younger age. This study is a part of an awareness program conducted in schools with primary school children at an early age so that the problem of foot deformities and other issues can be addressed at an early age. The children and their parents can be educated about foot-related issues and simple exercises and techniques for the protection of the foot structure at a younger age. Thus, the flat foot issue is significantly critical and must be prevented and controlled at an early age before it is converted into a serious medical condition at an older age. Medical camps and awareness programs in schools can be very useful for preventing and controlling foot deformities in children at a very early age. Further, an early assessment of flat feet can provide the basis for parents to select appropriate sports for their child.

5 Conclusion

In this work, we analyzed the association between age and gender with the prevalence of flat or partially flat feet. The results are validated on the dataset collected from 424 primary school children aged between 6 and 10 years. The results showed.

that there are 41.5% with partial flat feet and 27.83% with completely flat feet. Hence, in Indian children aged between 6 and 10 years the prevalence of flat feet or partial flat feet is high, almost 3 in every five children. There was no association found between age and the presence of flat feet. However, there was a significant association found between gender and the prevalence of flat feet. Hence, male children require close monitoring and are at higher risk of flat feet at an early age and females have partial flat feet at an early age, and if precautions and minor corrections are taken, it will prevent converting the partial flat feet into complete flat feet at an older age.

The study suggests an early assessment of the prevalence of flat feet in children so that preventive or corrective measures can be taken at an initial age of a child. This will not only improve the well-being and quality of life of an individual but also will help in making decisions about participation in appropriate sports.

In the future, further analysis of children aged between 10 and 15 years will be made to further gain insight into the prevalence of flat feet among these children.

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