Determination of flat foot by footprint analysis using plantar arch index in children aged between 5 and 14 years

P. Santhanam¹, K. Yuvaraj Babu², Karthik Ganesh Mohanraj²*

ABSTRACT

Introduction: The development of lower limb and foot structural modification distinguishes humans from other bipedal mammalian species. Flat feet, also known as acquired flat foot disorder, results from collapsed arches of the feet. Usually while standing in erect posture, the medial margin of the sole of foot will not touch the ground. However, an undeveloped or a fallen arch causes the foot to roll inwards, and the entire sole comes close to the ground. In this study, we aim to assess and analyze flat foot with reference to plantar arch index (PAI) in children. Materials and Methods: The study was conducted on 50 children aged between 5 and 14 years. Footprints of all the 50 subjects were obtained using simple ink print method. Staheli’s arch index was adapted to quantify standing foot morphology. The presence of flat feet is diagnosed, by calculating the PAI PAI = A/B. If the PAI is >1.15, then it is considered as flat foot. Results: The PAI values ranged from 0.41 to 1.28 with mean PAI being 0.66 on the right foot and 0.63 on the left foot. No significant differences were found between genders and between the different age groups. Among 50 subjects, seven children (four females and three males), i.e., 14% had flat feet deformity with PAI >1.15. Among them, 3 children (6%) had unilateral left flat foot and 2 children (4%) had unilateral right flat foot and the remaining two subjects had bilateral flat feet (4%). Conclusion: Children with elevated percentage of flat foot may be the result of the fact that outdoor games or any other physical activities among children and adolescents are rapidly decreasing in the modern world with growing number of overweight and obese children.

KEY WORDS: Aged people, Arch of foot, Flat foot deformity, Footprint, Plantar arch index

INTRODUCTION

The human foot has been structurally, functionally evolved and developed to be one of the most remarkable modifications in human evolution.[1] The human foot is a multifaceted structure adapted to allow orthograde bipedal stance and locomotion. It is the only part of the body which is in direct contact with the ground.[2] This advanced modification of foot is attained by its complex anatomical structure which is comprised foot bones, strengthened by ligaments and tendons allowing the foot to support the weight of the body in the erect balanced posture with least weight. These composite anatomical components form a rigid structure called the “arches of foot.” Three important arches are recognized in the feet which are the medial longitudinal arch, the lateral longitudinal arch, and the transverse arch.[3]

The presence of arched feet is one of the distinctive features of human evolution. In certain conditions, this arched foot becomes impaired and loses its contour leading to a deformity called “Pes planus.” It is a condition in which mostly the longitudinal arch of foot is impaired, and hence, the entire sole touches the ground making the sole of foot to flatten.[4] The most commonly occurring problems of the medial longitudinal arch are either because of the excessively high arch, a condition known as “pes cavus” or cavus foot or due to the extremely low arch known as “pes planus” or flat foot.[5] This has a significant impact on the foot function of the individuals and the development of the musculoskeletal pathologies.[6,7] They are believed to have a negative impact on the quality of life.[8]

Flat foot refers to the tenuous combination of anatomical variations and pathological changes.[9] The arch provides a flexible and springy effect between the forefoot and the hindfoot to adapt for uneven ground

¹Department of Anatomy, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India, ²Department of Anatomy, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India

*Corresponding author: Karthik Ganesh Mohanraj, Department of Anatomy, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, 162, Poonamallee High Road, Chennai - 600 077, Tamil Nadu, India. Phone: +91-9940545168. E-mail: karthikganesh.0446@gmail.com

Received on: 05-04-2018; Revised on: 12-05-2018; Accepted on: 22-06-2018
surfaces. During weight-bearing, the foot bones can be dissipated before majority of forces reaches the long bones of the thigh and leg. In flat foot, the head of the talus bone is displaced medially and distally from the navicular bone. As a consequence, the spring ligament of the foot (the plantar-calcaneonavicular ligament) and the muscle tendons are stretched so severely that the individual with flat foot loses the function of the medial longitudinal arch. This latter condition can be correctable with well-fitting arch supports. The appearance of flat foot in aged people is normal and common which masks the arch of the foot of the individuals.

Engel and Staheli proposed following the association between the arch region and the heel region, the assessment of the plantar arch development can be done. The foot plantar index is a diagnostic tool aimed at quantifying the foot posture to which a foot can be considered to be in the movement at pronation, supination, or neutral position. Foot posture is an important component of musculoskeletal assessment in clinical practice. Variations in foot posture influence the lower limb, muscle activity, balance, and functional ability. Several techniques such as visual observation, footprint parameters, measurement of frontal plane heel position, and assessment of the navicular tuberosity and range of angular measurements are carried out. In this study, we aim to assess and analyze flat foot among children aged between 5 and 14 years, using Staheli’s plantar arch index (PAI) method.

**MATERIALS AND METHODS**

The study was conducted on 50 children aged between 5 and 14 years. Footprints of all the 50 subjects were obtained using simple ink print method. A thin (1–2 cm width), large piece of sponge about 30 cm is placed on a tray and diluted ink is poured and wetted. The sponge absorbs all the ink and when the foot is placed, the ink sticks on the surface of the foot. The foot is then placed on a clean white sheet to mark the footprint.

Staheli’s PAI was adapted to quantify standing foot morphology. The presence of flat feet is diagnosed, by calculating the PAI. PAI is calculated by drawing a tangential line connecting the edge of medial forefoot and heel region. The mean point of this line is calculated. From this point, a perpendicular line is drawn crossing the footprint. The same procedure is repeated for heel tangency point. Width of the central point of the footprint is marked as “A” and the width of the central point of heel region is regarded as “B.” PAI is obtained by dividing the A value by B value.

Plantar arch index (PAI) = A/B.

If the PAI is >1.15, then it is considered as flat foot.

**RESULTS**

The morphological difference and the calculation of PAI between footprints of normal foot and flat foot is depicted in Figure 1. The PAI values ranged from 0.41 to 1.28 with mean PAI being 0.66 on the right foot and 0.63 on the left foot (Figure 2). No significant differences were found between genders (Figure 3) or between the different age groups (Tables 1 and 2).
Among 50 subjects, seven children (four females and three males), i.e., 14% had flat feet deformity with PAI >1.15. Among them, 3 children (6%) had unilateral left flat foot and 2 children (4%) had unilateral right flat foot and the remaining two subjects had bilateral flat feet (4%).

**DISCUSSION**

Our present study shows the prevalence of flat feet to be 14% (8% in female child and 6% in male child) among children aged from 5 to 14 years, which is comparatively less compared to a study conducted by Pfeiffer et al., where the prevalence of flat feet was 44% in a group of 3–6-year-old schoolchildren. This variation in the prevalence rate of flat foot may be due to the age limit set in these studies. The upper and lower age limit set for our study was from 5 to 14, whereas in other cited studies, it was from 3 and above, in which the lower age limit of 3 serves to be a major contributor of high percentage in flat foot.

The incidence of flaccid flat feet usually reduces with age as the child grows old. Engel and Staheli reported a strong reduction in flat foot up to the age of 4. This may be due to the reason that medial longitudinal arch development occurs mostly during that age; thus, higher PAIs are expected obviously in such young children, while these indexes are lower in comparatively older children. Still, several other studies state that major variations on plantar arch happen until the age of 7.

After a clear and thorough review of the literature made us to make a suggestion on this plantar index, which is having a decreasing incidence up to 5 years old and remaining stable after that was responsible for our decision to study a group of children above that age. Thus, analyzing PAIs with lower age groups could reduce the usefulness and efficiency of our indexes to the intended result.

Literature shows no significant difference PAIs between the right side and left side. However, one study reported that the plantar index showed a significant difference between sides. No significant differences were found in PAI for different ages. This finding is consistent to literature, which shows a higher level of medial longitudinal arch development and a strong decrease on flat feet incidence up to 5 years of age, tending to deviate little after that age. Following the study of PAIs, there were no significant differences found between genders which are in accordance with Staheli et al.

The most commonly used footprint analysis methods for diagnosing flat foot are using clinical diagnosis as the gold standard. The Staheli’s index, Clarke’s angle, and the Chippaux-Smirak index are regarded as reliable by many researchers. Our study adopted the method of Staheli’s index with slight modification of the method adopted by Hernandez et al. and Singrolay et al. to assess the footprints using simple ink print method.

Our study shows that the PAI method, we studied, is suitable for the diagnosis of flat foot in the children and has high sensitivity. Furthermore, simple ink print method is cost-effective and easier method of diagnosing flat feet compared to other techniques like radiography. It is, in fact, simple, easier to apply, and portable. This method is also non-invasive and does not involve radiation and hence can be applied in any kind of people immaterial of their age such as a baby, children, adolescent, adults, and even conditions such as pregnancy. Thus, it could be used clinically to diagnose flat feet under various scenarios.

**CONCLUSION**

From this study, we have two points to conclude. First, from the present study, we suggest that simple ink print method is a cost-effective and easier way of diagnosing flat feet deformity clinically using PAI, under any condition. Second, children having elevated percentage of flat foot are the result of the fact that outdoor games or other physical activities among children and adolescents are rapidly decreasing in the modern world with growing number of overweight and childhood obesity. In some cases, such flat feet in children cause minor postural difficulties and thus continue with ages prevailing until it causes severe detrimental effects.
REFERENCES


Source of support: Nil; Conflict of interest: None Declared