Original Research Article

Arch Check Tool: An Innovative Instrument to Measure Arch Height

Jyoti S. Jeevannavar[1], Shetty Priya Rajshekhar[2], T. V. Sandamini Kavindya Perera[2], Yogini A. Watwe[2], Poorvi Vadiraj Shingatgeri[2]

[1]Professor, SDM College of Physiotherapy, SDM University, Dharwad, Karnataka, India, [2]Intern, SDM College of Physiotherapy, Dharwad, Karnataka, India.

How to cite this article: Jyoti S. Jeevannavar, Shetty Priya Rajshekhar, T. V. Sandamini Kavindya Perera et. al. Arch Check Tool: An Innovative Instrument to Measure Arch Height. Indian Journal of Physiotherapy and Occupational Therapy / Vol. 18 No. 4, October-December 2024.

Abstract

Background: Pes planus, commonly known as flat foot is a deformity of the foot, characterized by loss of the medial longitudinal arch of the foot. There are several diagnostic methods available, such -as radiographs and digital footprint scanning techniques, that involve the usage of ink, dyes, and expensive instrumentation which may be harmful and not readily available at all time.

The arch height may prove to be a user-friendly, portable, and affordable means of grading the foot. However, no tools were found during the search for review of literature.

Hence, a need for a tool to measure the arch height and further give standard range of the arch height for flat feet and non-flat feet was identified.

Objective: To design a tool and further provide values to differentiate flatfoot and non-flatfoot using arch height as a measurement tool.

Relevance: The instrument was designed to quantify arch height and values to differentiate flatfoot and non-flatfoot are provided by comparison with Chippaux Smirak Index (CSI).

Method: The study evaluated the medial longitudinal arches of 30 individuals (60 feet) using static footprints and arch height measurement with tool. The footprints were classified into flatfoot and non-flatfoot using CSI. Data was subjected to appropriate statistical analysis.

Results: The range of medial longitudinal arch height between 15-21 mm in sitting position and 13-19 mm in standing position identified with non-flat foot, while the range of medial longitudinal arch height between 10-14 mm in sitting position and 8-12 mm in standing position identified with flat foot when compared with CSI. These findings suggest that the tool can be used effectively to measure the medial longitudinal arch height and differentiate between individuals with flat foot and non-flat foot.

Corresponding Author: T. V. Sandamini Kavindya Perera, Intern, SDM College of Physiotherapy, Dharwad, Karnataka, India.

E-mail: sandaminiperera97@gmail.com

Submission date: February 9, 2024 **Revision date:** June 27, 2024 **Published date: Oct 10 2024**

Conclusion: The study concludes that the tool is effective in measuring the medial longitudinal arch height and can be used to differentiate between individuals with flat foot and non-flat foot. Designers of the tool would like to name the tool as ArchCheck Tool.

Keywords: Flat foot; Arch Check tool; Arch Height; Static Footprints; Chippaux Smirak index

Introduction

The ankle and foot complex is composed of 28 bones that form 25 component joints, as well as muscles, nerves, vessels, and soft tissues. The bones of the foot are arranged into three arches, which are supported by various muscles and ligaments of the ankle-foot complex. The three arches are referred to as the Medial longitudinal arch, Lateral longitudinal arch, and transverse arch.[1]

There are three types of foot classified based on the medial longitudinal arch: [1] normal foot, [2] flat foot or pes planus, and [3]high arched foot or pes cavus.[2]

Pes planus(flat foot), is the commonest foot deformity that occurs when the medial longitudinal arch of the foot collapses, causing the sole of the feet to come closer to the ground or make contact with the ground while standing.[3]

Flat foot can be either congenital or acquired.[4]

Congenital flat foot can be caused due to genetic malformations, congenital vertical talus, congenital talipes equinovarusand acquired flat foot can be a result of obesity, posterior tibial tendon dysfunction, and ligamentous laxity in the spring ligament, plantar fascia or other supporting plantar ligaments also in medical conditions such as cerebral palsy, rheumatoid arthritis, and muscular dystrophy.[4]

Assessing flat feet can be done through various methods like ultrasound, which

Provides dynamic images of soft tissues in the foot, CT scans, which provide detailed 3D x-ray images of the foot, and MRIs, which provide detailed information regarding soft tissue abnormalities in the ankle foot complex. Each method has its advantages and limitations, and the choice of assessment method may depend on factors such as the scale of the study, cost considerations, and the specific information needed. Radiographs can be a reliable method for assessing the medial longitudinal arch, but they are less applicable for larger scale studies due to their cost and the risk of radiation exposure. As an alternative, footprints have been found to be a simple, fast, reliable, non-invasive, and inexpensive method for assessing flat feet. Footprint analysis has been employedto the radiographic method and has been used for qualification, categorization, and surveillance of pes planus.[4]

However, allergies to ink, messiness for foot prints and sensory issues may hinder the procedure. Thus it is important to develop other simpler methods to measure the medial longitudinal arch height with an as precise as possible tool. The arch height further needs to be identified for classification into flat foot or non-flat foot.

OBJECTIVE

To design a tool and further provide values to differentiate flatfoot and non-flatfoot using arch height measurement tool.

Materials and Methods

Inclusion criteria

Young adults from 18-25 years of age of either gender were requested to volunteer for participation in the study.

Exclusion Criteria

Volunteers with specific medical conditions that may significantly affect foot structure or function, such as severe arthritis, neuropathy, or foot deformities were excluded. Volunteers with recent foot injuries such as fractures or ligament injuries and those who had undergone recent foot or lower limb surgery were excluded. Those who regularly used orthopedic devices, such as orthotic insoles or custom footwear were also excluded.

Methodology

The study protocol was reviewed and granted approval by the Institutional Ethical Committeevide document number SDMIEC:0104:2015. A triangular

tool (Figure 1) with angles of 90º, 60ºand 30º was designed and further marked with standard mathematical graph paper to measure the height. A group of 50 young adults in the age group of 18 to 25 years were randomly selected and explained the need for the study and procedure for the same. A written informed consent was obtained from the 40 persons who volunteered for participation, and further screened for the study. 4 individuals had plantar fasciitis, 3 individuals reported an issue with the ink being used and 3 had a history of foot injuries in the past 6 months. Thus 10 individuals were excluded from the study and 30 participants were ultimately selected to be part of the sample.

The medial longitudinal arch height was measured twice in both the feet of the 30 participants and the highest reading was recorded. Static footprints were also obtained from all the participants at the same time. The footprints were further evaluated using the Chippaux Smirak Index for the classification of foot type. The measured arch heights were further correlated with the corresponding measurements derived from the arch height tool. The footprints were classified into flatfoot and non-flat foot and further subjected to data analysis of the arch height.

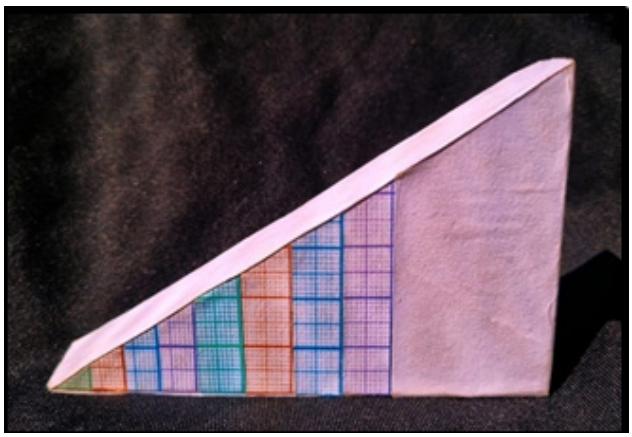

Figure 1: ArchCheck Tool

Method of Measurement of Arch Height: Arch height was measured in sitting and standing positions.

In Sitting: The participant was seated on a stool with hips and knees at 90 degrees of flexion and was instructed to maintain an erect spine with feet hip-width apart, looking straight forward. The arch height tool's smallest angle tip was placed at the highest visible point of the arch being tested. The tool was slid under the foot till the initial resistance was felt. The measurement for arch height was noted twice for each foot. The highest reading was recorded.

In Standing: The participant was asked to stand up from the stool and was instructed to look straight forward and equally weight bear on both feet. The tool was placed at the highest visible point of the arch being tested, and the participant confirmed if they perceived the tool to be at the middle of their foot. Adjustments were made if necessary based on the participant's directions, and the measurement for arch height was noted for each foot.

Method of footprint collection:

The individual was seated on a chair with the hip and knee flexed at 90 degrees each. A tray containing paint mixed with water was prepared. The participant was asked to place both feet in the tray. They were then advised to place both feet hip-width apart on a sheet of paper placed outside in front of the tray. They were asked to evenly distribute the weight on both feet and later move out of the sheet. The footprint created on the paper was assessed with CSI and the foot was classified thereafter.

Chippaux-Smirak Index was employed to measure the flatness of the footprint. The indices were determined by drawing two lines: one at the minimal distance of the midfoot region, one at the maximal distance of the forefoot area.

The Chippaux-Smirak Index is the ratio of the minimal distance of the midfoot regions (midfoot width CD) divided by the maximal width of the forefoot area (metatarsal width AB) multiplied by 100.[6] (Figure 2: A)

Figure 2: A. Chippaux Smirak Index = CD/AB x 100. B. Foot Print of a Normal Feet. C. Foot Print of a Flat Feet

Results

The data of 60 feet was subjected to data analysis. All analysis was done using Statistical Package for the Social Sciences (SPSS) version 23.0.

The data was analyzed for normality using Kolmogorov-Smirnov test and was found to be normally distributed. The baseline characteristics were assessed using Mean and Standard deviation for the descriptive statistics.

All calculations were done with a p-value ≤0.05 as statistically significant.

Table 1 presents the demographic information pertaining to the participants involved in the study.

Table 1: Demographic details of the participants

	MALES	FEMALES	TOTAL
NUMBER	15 (50%)	15 (50%)	30 (100%)
MEAN AGE YEARS (SD)	19.6 (±0.73)	19.6 (±0.50)	19.6 (±0.62)
UNILATERAL FLAT FOOT (as per CSI)	0	5 (16.7%)	5 (16.7%)
BILATERAL FLAT FOOT (as per CSI)	3 (10%)	2 (6.7%)	5 (16.7%)
NORMAL FOOT	12 (40%)	8 (26.66%)	20(66.6%)

The study comprised a sample size of 30 individuals, which included 15 (50%) females and 15 (50%) males with mean ages 19.6 (±0.73) and 19.6 (±0.50) respectively. The ages were not significantly different with a t-value of 0 at a p-value of 0.5.

Frequency distribution showed that 5 participants (all females) had unilateral flat foot while 5 participants (3 males and 2 females) had bilateral flat foot. The number of females affected with flat feet were 7 (23.4%) while males were 3 (10%). The number of females and males were not significantly different with a z-value of 1.3856 and p-value of 0.2. The feet wise distribution showed that 9 feet in females (15%) were flat while 6 feet in males (10%) were flat. The numbers were not significantly different at z-value of 0.8944 and p-value of 0.4.

Totally 15 (25%) feet out of 60 were flat while 45 (75%) feet were found to be normal. The number of flat feet was significantly lower than the number of normal feet at a z-value of -5.4772 and p-value of <0.00001.

Frequency distribution showed that 7 (46.7%) females were found have flat foot while 8 (53.3%) females were found to have normal foot. The number of females with flat foot and normal foot does not exhibit significant difference at a z-value of0.3651 and p-value of 0.7. Feet wise distribution showed that 9 (30%) feet of females were flat feet while 21 (70%) feet of females were found to be normal. The number of flat feet was significantly lower than the normal feet at z -value of 3.0984 and p value of 0.002.

Frequency distribution showed that 3 (20%) males were found to have flat foot while 12 (80%) males were found to have normal foot. The number of flat foot was significantly lower than the number of normal foot at a z–value of -3.2863 and p-value of 0.001. Feet wise distribution showed that 6 (20%) feet of males were flat feet while 24 (80%) feet of males were found to be normal. The number of flat feet was significantly lower than the normal feet at z–value of 4.6476 and p-value of <0.00001.

The mean arch heights of all the participants in sitting [Rt. 16.5 mm (±3.5),Lt.16.7 mm (±3.5)] and standing [Rt. 14 mm (± 3.6), Lt. 14 mm (±4)] were 17.6(±3.5) and 15.2(±3.8) respectively. The arch heights in sitting and standing were significantly different with the t-value of 3.77184 and p-value of 0.0003.

Comparison of arch height in sitting, between participants with flat foot[12 (±2)] and normal foot [18(±3)] as per CSI were significantly different with a t-value of 6.95886 at a p-value of<0.00001.

Comparison of arch height in standing, between participants with flat foot [10(±2)] and normal foot [16 (±3)] as per CSI were significantly different with a t-value of 6.90854 at a p-value of <0.00001.

Discussion

The included sample of participants was seen to be homogenous with equal distribution of females and males in the study. The results of our study showed that both female and male gender had equal probability of developing flat foot and this result

is supported by another study which reports that gender does not play any role in the occurrence of flat foot.[5]

The results also showed that an equal number of individuals had unilateral and bilateral flat foot. However a study shows that bilateral flat foot is more prevalent as compared to unilateral flat foot. The results of our study may not be in coherence with other studies and may be attributed to the very small sample size.[5]

The range of medial longitudinal arch height between 15 - 21 mm in sitting position and 13 -19 mm in standing position identified with non-flat foot, while the range of medial longitudinal arch height between 10 - 14 mm in sitting position and 8 -12 mm in standing position identified with flat foot when compared with CSI. These findings suggest that the tool can be usedeffectively to measure the medial longitudinal arch height and differentiate between individuals with flat foot and non-flat foot.

Conclusion

Study concludes that the tool is effective in measuring the medial longitudinal arch height and can be used to differentiate between individuals with flat foot and non-flat foot.

Conflict of interest: The authors have no conflicts of interest to disclose.

Source of Funding: Self

References

1. Norkin CC, Levangie PK. Joint structure & function: a comprehensive analysis. (No Title). 1992 Jan.
2. Jeevannavar JS, Kulkarni S, Ankolekar B, Nadgauda KP, Shilesh K, Bachgoudar RH. Intra-Rater and Inter-Rater Reliability of Foot Print Analysis Tool. Indian Journal of Physiotherapy & Occupational Therapy. 2018 Oct 1; 12(4)
3. Maheshwari J, Mhaskar VA. Essential Orthopaedics:(including clinical methods). JaypeeBrothers Medical Publishers; 2019 Feb 28.
4. Raj, MA, Tafti, D, Kiel, J. Pes Planus, StatPearls [Internet]. 2023 Mar 23. Available at: https://www.ncbi.nlm.nih.gov/books/NBK430802/ (Accessed: 06 February 2024).
5. Reddy G, Kishve P. Prevalence of flat foot among medical students and its impact on quality of life and functionality. International Journal of Research in Medical Sciences. 2021 Apr; 9(4):1082.
6. Jeevannavar JS, Watwe YA, Shingatgeri PV. Validity of Arch Height Measuring Tool inComparison with Chippaux-Smirak Index and Staheli's Arch Index: A Pilot Study. National Editorial Board. 2023 Oct;17(4):45.