Original Article

# Validity of Arch Height Measuring Tool in Comparison with Chippaux-Smirak Index and Staheli's Arch Index: A Pilot Study

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**Abstract**

**Background:** Flat foot is a postural deformity also known as pes planus is a condition where the arches of the foot collapse and the entire sole comes into contact with the ground when standing. Various tools are available to measure the extent of flatfoot which involves the usage of inks, dyes, expensive instrumentation, etc., which may be harmful and not available at all times. The arch height measuring tool is portable, easy to use, inexpensive and quick. However, the validity of this tool for flat foot is unknown and hence the objective of the study was to identify the same.

**Objective:** To determine the validity of the 'Arch Height Measuring Tool' designed by E-Soles Custom Footbeds as compared to Chippaux-Smirak Index and Staheli's Arch Index.

**Methods:** The medial longitudinal arches of the feet of 30 children with neurodevelopmental delay were assessed with static footprints evaluated using Staheli's Arch Index, Chippaux-Smirak Index and also using The Arch Height Measuring Tool. The footprints were classified into flatfoot and non-flatfoot and further subjected to data analysis.

**Results:** The tool when compared with the Chippaux-Smirak Index and Staheli's Arch Index was found to have a sensitivity of 30% and 28.3% respectively, specificity of 41.6% and 25% respectively and an accuracy of 72% and 75% in detecting flat feet in children with neurodevelopmental delay (NDD).

**Conclusion:** The study concludes that the Arch Height Measuring Tool with its current classifications is not suitable for diagnosing mild flatfeet due to the higher false negative results.

**Keywords:** Flatfoot; Deformity; Footprint Analysis; The Arch Measuring Tool; Chippaux-Smirak Index; Staheli's Arch Index.

## Introduction

The ankle and foot complex consists of 26 bones, >100 muscles, ligaments and tendons, 23 joints, and a network of nerves, skin, blood vessels, and soft tissues. Based on the structure of the medial longitudinal arch, 3 types of the foot have been classified: [1] Normal foot [2] Low arched or pronated or pes planus [3] High arched or supinated or pes cavus.[1]

Flatfoot is a postural deformity characterized by the medial longitudinal arch of the foot being in a

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collapsed position or is less developed where the sole comes into complete or near-complete contact with the ground.[2-3]

It can be caused by various factors including genetics, injury, or certain medical conditions such as rheumatoid arthritis, cerebral palsy, muscular dystrophy, congenital vertical talus, etc.[3]

Radiographs can be the direct method for assessing medial longitudinal arch, which is reliable too but is less applicable in larger scale studies due to the cost and risk of radiation exposure. Indirect methods of assessment such as the use of non-toxic coloured footprints which can be simple, fast, reliable, non-invasive, and inexpensive, have been linked to the radiographic method. Several reports suggest that footprint analysis can be used for qualification, categorization, and surveillance of pes planus or flat feet. The other methods of assessing flat feet include ultrasound which provides dynamic images of soft tissues in the foot; whereas CT scans provide detailed 3D x-ray images of the foot and MRIs also provide detailed information regarding soft tissue abnormalities in the ankle foot complex.[1]

The medial longitudinal arch can be measured from the footprints by using various standard tools like the Chippaux-Smirak index and Staheli's arch index. During the search for various tools for arch height measurement, a new tool called 'Arch Height Measuring Tool' was found, however, the validity of the same was not found. The tool may be highly accurate, and consistent, reducing the chance of human error, which may occur while using footprints. It would be safer as compared to the use of various colours, dyes and hence decreasing the risk of toxicities and allergic reactions. It will not only provide objective data but also provide faster assessment saving both time and energy. It is more portable and can be used in different locations making them more accessible for arch-related assessment. Overall, it may provide more precise and consistent data. Hence, the study aimed at finding the validity of this new tool as compared to gold standard footprint assessment methods.[1]

**Objective**

To determine the validityof the 'Arch Height Measuring Tool' designed by E-soles Custom Footbeds as compared to CHIPPAUX-SMIRAK INDEX and STAHELI'S ARCH INDEX.

## Materials and Methods

**Inclusion criteria**

Childrenfrom 2-16 years of age of either gender diagnosed with neurodevelopmental delay that could stand or walk with or without assistance.

**Exclusion criteria**

Children with typical development were excluded from the study. Children with NDD who had a history of lower limb injury or trauma, and a history of botox administration for the lower limbs 6 months prior to data collection. Children with congenital lower limb amelia were also excluded from the study.

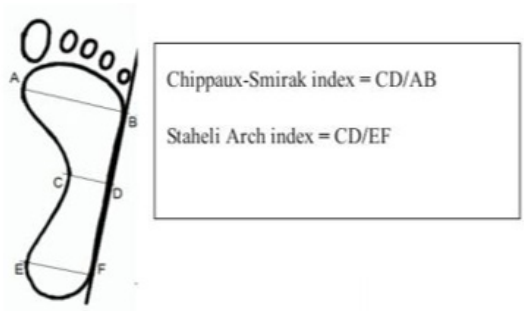


**Figure 1: Foot Print Analysis[1]**

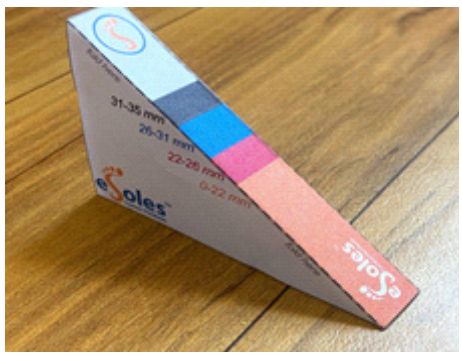


**Figure 2: Arch Height Measuring Tool**

## Methodology

The Institutional Ethical Committee examined and approved the study's protocol. The data was collected in the out-patient department of paediatric physiotherapy on the premises of the tertiary hospital, from March 2023 to June 2023. Using G.

Power Software (Version 3.1.9.2) the total sample size for the Exact test for a set a-error probability of 5%, power of the statistical test (1-β error probability) 95% and an effect size of 0.8 (α =0.5, power=0.95%, r>0.7)was calculated to be 59 feet with the parameters set at 2 tails.

Considering that 10% of parents would not consent to the child's participation an additional 6 feet were added. Therefore, the sample size was 65 which were rounded off to 66 (thus the sample size of 33 children was taken).

33 children between 2 and 16 years of age with neuro developmental delay were chosen for participation in the study. The study's methodology and goals were explained to the parents of these children. Parents of 2 children did not consent to their child's participation during the preliminary demographic data collection. As a result, 31 children whose parents consented to their child's participation and also met the inclusion and exclusion requirements were chosento participate in the data collection.

The parents of the children who were a part of the study provided their written approval. Static footprints of these children were taken using non-toxic colour and subsequently subjected to the Staheli's Arch Index and Chippaux-Smirak Index for assessment of the medial longitudinal arch.

Chippaux-Smirak Index and Staheli's Arch Index were employed to measure the flatness of the footprint. The two indices were determined by drawing three lines: one at the minimal distance of the midfoot region, one at the maximal distance of the forefoot area, and one at the maximal distance of the rear-foot region. (Figure 1)

The Staheli's Arch Index (Figure 1) is the ratio of the minimal distance in the midfoot region (mid-foot width CD) to the maximal distance in the rear-foot region (heel width EF).

The Chippaux-Smirak Index is the ratio of the minimal distance between the midfoot regions(mid-foot width CD) divided by the maximal distance in the forefoot area (metatarsal width AB).


**Figure 3: Footprints Of A Child With Ndd**

## Results

Footprints of 2 feet which were not found to be appropriate for analysis with Staheli's Arch Index and Chippaux-Smirak Index were excluded and the data of 60 feet was thus subjected to data analysis.

The data of 60 feet was statistically analysed using Statistical Package for the Social Sciences (SPSS) version 23.0. The descriptive statistics were first evaluated using Mean and Standard deviation for the baseline characteristics.

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

Table no. 1 shows all the demographic details of the participants included in the study.

The sample included 30 children which consisted of 9 (30%) girls and 21 (70%) boys with mean ages 5.2 (±2.7) and 5.3(±4.2) respectively.

The Z score for population proportion showed that the number of boys was significantly higher as compared to that of girls at a Z value of -3.0984 at a p-value of 0.002.

The ages of boys and girls when subjected to a t-test for independent means, showed that the ages were not significantly different with a t-value of 0.25049 and the p value of 0.8.

The number of flatfeet [36(60%)] was found to be significantly higher than the number of non-flatfoot [24(40%)] at a z score of 2.19 and p-value of 0.03.

The tool when compared with the Chippaux-Smirak Index and Staheli's Arch Index was found to have a sensitivity of 30% and 28.3% respectively.The specificity when compared with the CSI and SAI was found to be 41.6% and 25% respectively.The accuracy with which the tool gave the true positives and true negatives was 72% and 75% when compared with CSI and SAI respectively.The false negative results as compared to CSI and SAI were 28.3% and 25% respectively.

**Table 1: Demographic details of the participants**

| | BOYS | GIRLS | TOTAL |
|---|---|---|---|
| NUMBER (%) | 21 (70%) | 9 (30%) | 30 (100%) |
| MEAN AGE YEARS (SD) | 5.3(±4.2) | 5.2(±2.7) | 10.5(±6.9) |
| FLAT FOOT | 36(60%) | | z = 2.19 |
| NON-FLAT FOOT | 24(40%) | | p = 0.03* |
| * p < 0.05 was statistically significant | | | |

**Table 2: Comparison of the Arch Height Measuring Tool with CSI and SAI**

| ARCH HEIGHT MEASURING TOOL | CSI | SAI |
|---|---|---|
| SENSITIVITY % | 30 | 28.3 |
| SPECIFICITY % | 41.6 | 25 |
| POSITIVE PREDICTIVE VALUE % | 41.80 | 37.7 |
| NEGATIVE PREDICTIVE VALUE % | 29.9 | 36.3 |
| FALSE NEGATIVE % | 28.3 | 25 |
| ACCURACY% (TRUE POSITIVE+TRUE NEGATIVE) | 72 | 75 |

## Discussion

The data obtained from 30 children's 60 feet were subjected to data analysis.

The number of boys in the study were significantly higher. This result is supported by other articles which also report the same.[4-6]

The results also show that children with NDD have a greater predisposition to develop flat feet.The number of feet with extreme flatfoot (where the total medial arch was in contact with the surface and the tool could not be inserted below the foot) were the only ones which were diagnosed as flatfoot by the arch height measuring tool. Whereas, mild flatfeet could not be identified by the tool as the lowest category identifiable was a medium arch. This could have been the reason for a large number of false-negative results of flatfeet. Thus, decreasing the validity of the tool in identifying mild flatfeet.

## Conclusion

The study concludes that the Arch Height Measuring Tool with its current classifications is not suitable for diagnosing mild flatfeet. Hence future studies with some additional classifications may make the tool valid for diagnosing all levels of flatfeet.

Ethical clearance: SDM Ethics committee, Date of approval: 10/12/2018, Reference Number: SDMIEC:092:2018. Written informed consent was obtained from all participants prior to their inclusion in the study.

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