Thrita Journal of Medical Sciences. 2013 September; 2(3): 15-8. DOI: 10.5812/thrita.9115
Published Online 2013 August 26. **Research Article**

Comparison of Arch Index of Flat Foot and Healthy Foot in Pre-school Children

Ensieh Pourhoseingholi [1], Mohamad Amin Pourhoseingholi [2,*]

[1] Orthosis and prosthesis Department, Tehran University of Medical Sciences, Tehran, IR Iran
[2] Department of Biostatistics, Shahid Beheshti University of Medical Sciences, Tehran, IR Iran

*Corresponding author: Mohamad Amin Pourhoseingholi, Department of Biostatistics, Shahid Beheshti University of Medical Sciences, Tehran, IR Iran. Tel: +98-2122432515, Fax: +98-2122432517, E-mail: Amin_phg@yahoo.com.

Received: November 13, 2012; **Revised:** December 19, 2012; **Accepted:** March 10, 2013

Background: The validity of clinical measurements such as Arch Index for the evaluation of flat foot has not been fully established for the physicians.
Objectives: We conducted this study to compare the Arch Index (AI) and Foot Posture Index (FPI) between normal and flat foot children and to assess the differences between the pattern of arch and score of FPI.
Patients & Methods: Clinical measurements of AI and FPI were performed on 40 subjects (18 boys and 22 girls), aged from 5 to 7 years referred to Adabian Rehabilitation Center, Kermanshah, Iran. The study was carried out from May to September, 2012. These clinical measurements were then compared according to AI and FPI in right and left foot between healthy and flat foot children.
Results: All two clinical measures demonstrated significant associations for left and right foot between healthy and flexible flatfoot of children ($P < 0.05$). Mann-Whitney test showed that the mean of AI for the left and right foot in healthy children was significantly lower than flatfoot children ($P < 0.001$). Also, the mean of FPI for the left and right foot in healthy children was significantly lower compared to the corresponding foot in flatfoot children ($P < 0.001$).
Conclusions: According to our results, these clinical measurements would provide valid information regarding the structure of the medial longitudinal arch.

Keywords: Flatfoot; Arch; Children

1. Background

Childhood flexible flat foot is the most common condition of the lower limb (1), in which the medial longitudinal arch of the foot collapses during weight bearing and restores after removal of body weight (2-4). The true prevalence of flatfoot is unknown, primarily because there is no consensus on the strict clinical or radiographic criteria for defining a flatfoot (5). But some authors reported that the prevalence of flexible flatfoot in children, (2 to 6 years of age) is between 21% and 57%, and the percentage has decreased to 13.4% and 27.6% in primary school children (6, 7). Generally, infants are born with flexible flatfoot (6). The development of foot arch is rapid between 2 and 6 years of age (7) and becomes structurally matured around 12 or 13 years of age (2, 8). Concern about a child's flat foot is a common reason for frequent clinical consultations with an array of healthcare and medical professionals (5). The clinical assessment of a child with a flatfoot should consist of a general examination of the musculoskeletal system, in addition to the specific foot and ankle examination and rapid and uneven shoe wear in older children and adolescents, so the child's shoes should be examined as well.

Evaluation of the heel-to-arch width ratio on the footprints of children is another method in diagnosis. Staheli et al. (9) used the footprint technique for the first time to evaluate the shape of the plantar surface (5, 10). A vast array of techniques have been used, including visual observation, (11-14) various footprint parameters, (15, 16) measurement of frontal plane heel position (17, 18) and assessment of the position of the navicular tuberosity (19, 20). Although the reliability of clinical measures of static foot posture have been widely debated (20) each of these techniques has advantages and disadvantages in relation to equipment requirements, the degree of clinical expertise necessary to obtain accurate measurements, reliability and validity considerations, relationship to dynamic foot function and the availability of normative data for comparison purposes (21). Comprehensive, normative radiographic values have recently become available for the adult foot (22).

2. Objectives

The objective of this study was to compare the Arch In-

Implication for health policy/practice/research/medical education:
It would be beneficial for researchers in the field of rehabilitation.

dex (AI) and Foot Posture Index (FPI) between normal and flat foot children and determine the differences between the pattern of arch and score of FPI. The data may be used to distinguish between the two groups (healthy and flat foot) and help them make a good decision including only observing the low arch, using assistive device (insole or shoe) or performing exercises.

3. Materials and Methods

We carried out this cross-sectional study on twenty pre-school children (age from 5 - 7 years) with flexible flatfeet and twenty pre-school children (age from 5 - 7 years) with normal arches from May to September 2012. We recruited our participants from flatfoot patients who had referred to the Adabian Rehabilitation Center, Kermanshah, Iran. Healthy children were also randomly recruited from pre-school children. None of the subjects had pain in lower extremity including foot and ankle. Subjects were excluded if they presented pain or deformity. For measuring both AI and FPI in this study, a static footprint was obtained using pedoscope imprint, with the subject standing in relaxed position. A foot axis was then drawn from the center of the heel to the tip of the second toe, and the footprint was divided into equal thirds (excluding the toes) by constructing lines tangential to the foot axis. The AI was calculated as the ratio of area of the middle third of the footprint to the entire footprint area.

The FPI is a system for observing and rating static foot posture, incorporating seven criteria with the subject standing relaxed in a bipedal position:

1. Talar head palpation: The head of the talus is palpated on the medial and lateral side of the anterior aspect of the ankle, and the degree of medial or lateral prominence is documented. In a pronated foot, the talar head will be more palpable on the medial side, whereas in a supinated foot, the talar head will be more palpable on the lateral side.

2. Supralateral and infralateral malleolar curvatures: The curves above and below the lateral malleolus are observed. In a pronated foot, the curve below the malleolus will be more acute than the curve above due to the valgus orientation of the foot, and the opposite is observed in the supinated foot.

3. Frontal plane alignment of the calcaneus: The posterior aspect of the calcaneus is visualized and degree of eversion/inversion of the heel is documented. A pronated foot will demonstrate a more everted heel position and a supinated foot will exhibit a more inverted heel position.

4. Prominence in the region of the talonavicular joint: The skin immediately superficial to the talonavicular joint is observed. In a pronated foot, the talonavicular joint will be more prominent, whereas in a supinated foot the talonavicular area will be indented.

5. Congruence of the lateral border of the foot: The lateral border of the foot is viewed from posterior viewpoint. Pronated foot will exhibit a concave profile, whereas a supinated foot will exhibit a convex profile.

6. Abduction/adduction of the forefoot on the rearfoot: When viewed from directly behind, a pronated foot will result in more of the forefoot being visible on the lateral side due to forefoot abduction, whereas a supinated foot will result in more of the forefoot being visible on the medial side due to forefoot adduction.

Each of these criteria are scored on a 5-point scale (ranging from –2 to +2) and the results recombined, result in a summative score ranging from –12 (highly supinated) to +12 (highly pronated) (23). The reliability study followed standard protocol as a same subject, repeated measures investigation by three times and use the mean of measurements. Each child removed his/her shoes and socks and stood on a low table approximately 0.5 m in height. The child was asked to look straight ahead (out of a window) while his/her feet were examined. Examiner observed the child's feet and recorded their findings via Flexible Flat Foot (FFF). Each child's gait was also briefly observed by the examiner. The total foot examination time took approximately five to 10 minutes for each child. The second and third examination sessions took place at least one week after the first session. After that we used the average of the numbers. Wilcoxon test was employed to compare the measurements of AI and FPI in right and left foot (inside each group) and Mann-Whitney test was used to compare each index between healthy and flatfoot groups.

4. Results

Twenty healthy children (12 girls and 8 boys) and 20 flatfoot children (10 girls and 10 boys) aged between 6-7 years entered the study (Table 1). According to the results, the mean ± SD scores of AI for the left foot and right foot were 0.214 ± 0.139 and 0.221 ± 0.129, respectively. There was a significant difference between left and right foot according to AI measurement in healthy children ($P = 0.022$). The mean ± SD of FPI in healthy left and right foot was 0.55 ± 1.23 and 1.05 ± 1.50 respectively. There was no significant difference between left and right foot according to FPI measurement in healthy children ($P = 0.102$).

Table 1. Demografic Characteristics of two Groups

	Gender	Mean age, y	Mean Weight, Kg	Number
Healthy Group	Girl	6.0	24	12
	Boy	6.3	26.2	8
Flat foot Group	Girl	6.1	24.8	10
	Boy	5.9	21.0	10

The mean ± SD of AI in left and right foot in flatfoot children were 0.29 ± 0.33 and 0.30 ± 0.25 respectively. There was a significant difference between left and right foot according to AI measurement in flatfoot children (P = 0.021). The mean ± SD scores of FPI in left and right foot in flatfoot children were 6.95 ± 1.31 and 7.40 ± 0.94 respectively. There was also a significant difference between left and right foot according to FPI measurement (P < 0.001) (Table 2).

Table 2. The Mean ± SD of AI and FPI for Healthy Children and Flat Foot Children

	Index	Left, Mean ± SD	Right, Mean ± SD	P Value
Healthy Group	AI[a]	0.214 ± 0.14	0.221 ± 0.13	0.022
	FPI[a]	0.55 ± 1.23	1.05 ± 1.50	0.102
Flat foot Group	AI	0.293 ± 0.33	0.301 ± 0.26	0.021
	FPI	6.95 ± 1.31	7.40 ± 0.94	< 0.001

[a] Abbreviations: AI, Arch Index; FPI, Foot Posture Index

Mann-Whitney test showed that the means of AI for the left foot and right foot in healthy children were significantly lower than flatfoot children (P < 0.001). Also, the means of FPI for the left foot and right foot in healthy children were significantly lower than the corresponding foot in flatfoot children too (P < 0.001).

5. Discussion

The objectives of this study were to develop a visual and actual assessment tool, based on the AI and FPI and present the differences between AI and FPI in right and left foot of healthy children, compared to flatfoot children. Our results indicated that there are statistically significant differences between the two groups according to AI and FPI measurements. The prevalence of flatfoot children in the population of young children is high (around 15%) (2). Cavanagh and Rodgers estimated the mean of AI score for normal population equal to 0.23 (SD = 0.04, range 0 to 0.36) (11). Based on this approach, a low AI-indicative of a flatter foot- was defined as > 0.26 and a high AI -indicative of a highly arched foot- was defined as < 0.21. In our study, AI scores ranged from 0.20 to 0.35 and were normally distributed, thus two categories were created: normal (± 1 SD from the mean) and low (> 1 SD from the mean). The AI scores that defined each category were as follows: (normal -between 0.21 to 0.28) and low (> 0.28). Then, a visual tool was created using only the scanned picture. The results of our study showed that AI for left and right foot in healthy children was significantly different, which was in the range of previous studies. The amounts of AI and FPI in left and right flatfoot children were significantly different. Other studies used only one footprint (right) because of its convenience and the independence assumption of statistical analysis (8, 11) as it would help for performing parametric tests. But according to our study, there was a significant difference in AI of right and left foot, and to evaluate the almost exact score we had to use the mean of each foot separately (11).

Some authors disagree with the application of imprint instrument and only believe in visual examination (7, 11). However, the degree of contact is particularly unclear in the medial arch region, so when comparing the imprint to the visual tool, the examiners may have assumed that slight contact is no contact and thereby offset the AI classification toward a higher arch (18). Nevertheless, we believe that the degree of misclassification is within acceptable limits, given the high overall percentage agreement. Based on our findings and other studies, it would appear that the AI visual assessment scan or ink imprint is worthy of consideration, when selecting a foot posture measurement in clinical practice or research settings. The AI also offers some key advantages over other clinical measurements, as it is highly reliable and correlated with navicular height and angular medial arch measures determined from radiographs. It is correlated with pressures under the midfoot and rearfoot motion during gait, and is able to discriminate between foot types based on age and presence of musculoskeletal conditions such as plantar fasciitis, midfoot osteoarthritis and medial compartment knee osteoarthritis. Finally, it is a reliable score to reduce the upset of parents and help orthotist to make a good decision about using insoles or shoes (8, 11).

According to this study, the amount of FPI between left and right foot were significantly different for both healthy children and flatfoot children. We found FPI as a fast, simple method of visually classifying foot postures as pronated, supinated or normal based on six different visual foot posture criteria. Every criterion of FPI in our study was significantly different. This finding was according to other studies, which used this index in evaluation of different foot abnormalities (8, 20). The FPI has demonstrated moderate to good intra-rater and inter-rater reliability as well as criterion validity. Furthermore, classification of foot posture based on FPI is associated with the development of various overuse injuries of the lower extremity and is related to dynamic foot function (14). In addition, these values were collected on a relatively large number of subjects to create normative values. Such measurements, particularly arch height, have also been associated with the development of lower extremity overuse injuries. In this study and some other studies, authors used AI and FPI to measure two and three dimensional characters of the foot. Finally, such indices help us diagnose and prescribe the method of treatment. Both AI and FPI, seem to be appropriate clinical test for the measurement of arch, as they are simple to perform, require minimal equipment and provide a valid representation of both two and three dimensional measurement of foot arch.

The limitation of this study was its small sample size due to the scarcity of cases with flat foot. So we could only enroll 20 children in the flat foot group during 6 months; however, the results would be useful as a pilot study for further researchers.

Acknowledgements

The authors appreciate all personnel of Adabian rehabilitation center, Kermanshah, for their helps.

Authors' Contribution

Ensieh Pourhoseingholi has conceived and designed this study. Mohamad Amin Pourhoseingholi has participated in writing and revising the manuscript. Both authors contributed in data analysis and drafting the results.

Financial Disclosure

There is no financial disclosure in this study.

Funding/Support

The authors fund this study themselves without financial supports from any organizations.

References

1. Shih YF, Chen CY, Chen WY, Lin HC. Lower extremity kinematics in children with and without flexible flatfoot: a comparative study. *BMC Musculoskelet Disord*. 2012;**13**:31.
2. Vittore D, Patella V, Petrera M, Caizzi G, Ranieri M, Putignano P, et al. Extensor deficiency: first cause of childhood flexible flat foot. *Orthopedics*. 2009;**32**(1):28.
3. Menz HB. *Foot Problems in Older People: Assessment and Management*. 2008.
4. Bonnet WL, Baker DR. Diagnosis of pes planus by x-ray. *Radiology*. 1946;**46**:36-45.
5. Riccio I, Gimigliano F, Gimigliano R, Porpora G, Iolascon G. Rehabilitative treatment in flexible flatfoot: a perspective cohort study. *Chir Organi Mov*. 2009;**93**(3):101-7.
6. El O, Akcali O, Kosay C, Kaner B, Arslan Y, Sagol E, et al. Flexible flatfoot and related factors in primary school children: a report of a screening study. *Rheumatol Int*. 2006;**26**(11):1050-3.
7. Pfeiffer M, Kotz R, Ledl T, Hauser G, Sluga M. Prevalence of flat foot in preschool-aged children. *Pediatrics*. 2006;**118**(2):634-9.
8. Volpon JB. Footprint analysis during the growth period. *J Pediatr Orthop*. 1994;**14**(1):83-5.
9. Staheli LT. Planovalgus foot deformity. Current status. *J Am Podiatr Med Assoc*. 1999;**89**(2):94-9.
10. Whitford D, Esterman A. A randomized controlled trial of two types of in-shoe orthoses in children with flexible excess pronation of the feet. *Foot Ankle Int*. 2007;**28**(6):715-23.
11. Menz HB, Fotoohabadi MR, Wee E, Spink MJ. Visual categorisation of the arch index: a simplified measure of foot posture in older people. *J Foot Ankle Res*. 2012;**5**(1):10.
12. Cobb SC, Tis LL, Johnson BF, Higbie EJ. The effect of forefoot varus on postural stability. *J Orthop Sports Phys Ther*. 2004;**34**(2):79-85.
13. Spink MJ, Fotoohabadi MR, Wee E, Hill KD, Lord SR, Menz HB. Foot and ankle strength, range of motion, posture, and deformity are associated with balance and functional ability in older adults. *Arch Phys Med Rehabil*. 2011;**92**(1):68-75.
14. Menz HB, Morris ME. Clinical determinants of plantar forces and pressures during walking in older people. *Gait Posture*. 2006;**24**(2):229-36.
15. Nigg BM, Cole GK, Nachbauer W. Effects of arch height of the foot on angular motion of the lower extremities in running. *J of biomechanics*. 1993;**26**(8):909-916.
16. Menz HB, Munteanu SE, Zammit GV, Landorf KB. Foot structure and function in older people with radiographic osteoarthritis of the medial midfoot. *Osteoarthritis Cartilage*. 2010;**18**(3):317-22.
17. Yalcin N, Esen E, Kanatli U, Yetkin H. Evaluation of the medial longitudinal arch: a comparison between the dynamic plantar pressure measurement system and radiographic analysis. *Acta Orthop Traumatol Turc*. 2010;**44**(3):241-5.
18. Elvira JL, Vera-Garcia FJ, Meana M. Subtalar joint kinematic correlations with footprint arch index in race walkers. *J Sports Med Phys Fitness*. 2008;**48**(2):225-34.
19. Spink MJ, Menz HB, Fotoohabadi MR, Wee E, Landorf KB, Hill KD, et al. Effectiveness of a multifaceted podiatry intervention to prevent falls in community dwelling older people with disabling foot pain: randomised controlled trial. *BMJ*. 2011;**342**:d3411.
20. Murley GS, Menz HB, Landorf KB. A protocol for classifying normal- and flat-arched foot posture for research studies using clinical and radiographic measurements. *J Foot Ankle Res*. 2009;**2**:22.
21. Kanatli U, Yetkin H, Cila E. Footprint and radiographic analysis of the feet. *J Pediatr Orthop*. 2001;**21**(2):225-8.
22. Mosca VS. Flexible flatfoot in children and adolescents. *J Child Orthop*. 2010;**4**(2):107-21.
23. Hylton B, Menz B, Shannon E, Redmond A, Burns J, Crosbie J, et al. An initial-Validity of 3 Clinical Techniques for the Measurement of Static Foot Posture in Older People. *J Orthop Sports Phys Ther*. 2001;**31**:160.