ORIGINAL ARTICLE

www.ijrdh.com
ISSN: 2321 - 1431

Normative Data for Foot Posture Index (FPI-6) and Association of Foot Posture with Anthropometric Parameters in School Children from Mangalore: A Cross Sectional Study

Public Health

Baisakhi Das,Vijaya kumar K*, Dr Jaya Shanker Tedla Ph.D, Dr Amitesh Narayan Ph.D#**

ABSTRACT

Background: The Foot Posture Index (FPI) is a validated method for quantifying standing foot posture, and is used in a variety of clinical and research settings. However, there have been no retrievable normative data available to date for comparison and reference, for Indian children.

Aim: This study aimed at investigating normal foot development and establishing normative FPI-6 reference values of typically developing school children in Mangalore and also at finding the association of foot posture with anthropometric parameters.

Methods: 240 children of the group of 6 to 11 years of age were evaluated according to the procedure mentioned in The Foot Posture Index (FPI-6) User Guide and Manual.

Results: Prevalence of pronated feet was more common in 6-year old children .Age had a significant effect on all six components of FPI-6 scores for both sexes. A significant association was found between FPI-6 and gender in the age group of 9 years. No correlation was found between anthropometric parameters and foot types in the above-mentioned age groups.

Conclusion: The normative data of Foot Posture Index for children from 6-11 years of age was established in the present study. This can also be used to monitor the outcome of the rehabilitation process in foot impairments

***Key words:* Foot and Ankle, Flat foot in Children, Foot Posture Index**

Introduction

The ankle and foot complex play a critical role in maintaining erect posture, as also in adaptation to supporting surfaces, in correcting postural sway in single limb stance, in shock absorption and in transition of ground reaction force (GRF) in order to aid the push off during normal gait [1]. Functional variance and minimal biomechanical alterations in the ankle and foot complex in turn alters the contact with the surface area and the peripheral sensory input in weight-bearing posture [2,3]. Changes in neuromuscular strategies alter the ability to maintain a stable and upright posture, and anticipatory postural control is reduced, increasingly predisposing the individual to falls and associated injuries [4]. Structural deviations in the ankle and foot complex predispose the individual to changes in weight bearing, muscle imbalance static as well as dynamic balance in ambulation resulting in compensatory strategies which often predispose the individual to overuse injuries [5-8].

Knowledge of normal foot posture in typically developing children helps to outline rehabilitation strategies most appropriate for the affected children as well as to monitor the progress with intervention [9-11]. Common methods available to measure foot posture in pediatric population are visual assessment, subjective clinical observations, radiographic appraisals, two-dimensional video analysis, anthropometric values,

footprint measures, arch index, valgus index, rear foot angle, navicular height, foot posture index etc [12,13].

The Foot Posture Index (FPI), which was developed by Redmond AC [14] in 1998, provides quantitative measurements of the typical deviations of foot posture and is sensitive enough to detect any structural dysfunction in the forefoot, midfoot and rearfoot in the frontal, sagittal and transverse planes. It can be used as a screening tool for different inclusion and exclusion criteria in clinical research. This clinical tool can also be used to monitor the outcome of different rehabilitation strategies [15]. FPI-6, a revised version of FPI, was derived from the original eight-item scale. In the new version, two items were removed due to lack of unidimensionality. FPI-6 is said to have moderate to good inter-rater (0.62 to 0.91) and intra-rater (0.81 to 0.91) reliability as well as instrument validity (64%) in measuring foot posture [16,17].

Normative values for the Foot Posture Index (FPI-6) by Redmond et al [14] in 619 adult subjects were obtained and compared to those of 388 subjects aged 3 to 17 years. This study stated that the age and presence of pathology influences foot posture while gender and BMI (body mass index) does not have any effect. A recent study using FPI-6 was conducted by Target et al [10] on 225 children aged 3 to 11 years in the UK and normative values were established. The results of this study suggested that there is an increased occurrence of flat foot in 3 year-old children and a gradual decrease of flat foot with increasing age. The pronated foot in younger children is said to get corrected itself with increasing age.

Various authors have suggested that some external factors like anthropometry and BMI, which varies across children of different ethnic groups are said to affect foot postures in typically developing children [18-20]. There is also a significant difference in height (12%) and weight (30%) between children in developing countries and those of western countries, and further research on foot posture development is suggested for more comprehensive information [10,21]. There is a need to establish normative values of Foot Posture Index (FPI-6) for Indian children. The aim of the present study was to establish normative values of Foot Posture Index (FPI-6) in typically developing school children in Mangalore and to determine the association of foot posture with anthropometric parameters.

Materials & Methods

The study was approved by Institutional Ethics Committee KMC, Mangalore, Manipal University. Permission from the Block Education Officer (BEO) was taken and the three schools were selected randomly from the list. 240 Children from the age group of 6 to 11 years were recruited from three schools of Mangalore and were divided into subgroups of 6, 7, 8, 9, 10 and 11 years of age with 40 in each group (20 Boys and 20 Girls) from March-2012 to March 2013. Sampling was done according to stratified random sampling for age and sex. Permission from the school authorities to carry out the study was taken. The classes where the target population was located were identified. A call for staff members in each of the three schools to identify the target group. The Parental consent form, subject assent form, and screening form were sent home with every six-, seven, eight, nine, ten and eleven year child in every elementary school. From the classes, children were selected according to random number table. Children with any history of congenital malformation and/or previous surgery of the lower extremities, any neuromuscular or musculoskeletal abnormalities that may affect their performance of unsupported standing were excluded from the study.

The testing place was arranged prior to the test. Demographic data of the children were filled. Height was checked using a standard measurement tape, weight was checked using a weighing machine and the data was documented. The subject was asked to stand still in a relaxed double limb support stance, arms by the sides and looking straight ahead. Prior to settling into the required stance, it was helpful for the subject to do spot marching. The subject was instructed not to try to look downwards during the assessment, as this would affect foot posture. The subject was required to stand for approximately 2 minutes for the test to be conducted. The tester had uninterrupted access to all aspects of the leg and foot.

The FPI consists of six validated, criterion-based observations of the rearfoot and forefoot of a subject standing in a relaxed position. The rearfoot is assessed via palpation of the head of the talus, observation of the curves above and below the lateral malleoli and the extent of the inversion/eversion of the calcaneus. The

observations of the forefoot consist of assessing the bulge in the region of the talonavicular joint, the congruence of the medial longitudinal arch and the extent of abduction/adduction of the forefoot on the rearfoot .Each of the six parts of FPI-6 are evaluated on a scale from -2 to +2. The neutral position of the foot is classified as 0, during which the pronation takes on a positive value while the supination a negative value. The total FPI-6 result allows one to classify the foot into the following categories: from 0 to +5: neutral foot (correct), from +6 to +9: slight foot pronation, from +10 to +12: increased foot pronation, from -1 to -4: slight foot supination, from -5 to -12: increased foot supination [14]. Assessment of foot posture was carried out as stated below and the child's score was noted in the FPI-6 score sheet. All six items of FPI-6 were evaluated according to the procedure mentioned in The Foot Posture Index User Guide and Manual [22].

Data Analysis

Descriptive statistics was used to obtain normative values of FPI for each age group based on mean and standard deviation (SD). The Kruskal Wallis test was used to determine the association between age and foot posture score (FPI-6). Mannwhitney U test was used to find association between gender and foot posture score (FPI-6). Spearman's correlation coefficient was used to find association between anthropometric parameters i.e. height, weight and BMI and foot posture. Statistical Package for Social Sciences (SPSS) version 13.0 was used for analysis with p value < 0.05.

Results

Table 1 Demographic Data of Children. A total of 240 children aged from 6 to 11 years with each group consisting of 20 males and 20 females. The BMI values of the children taken for the study are in agreement with Indian norms.

Table 1: Demographic data of children included in the study

Age (Yrs)	Gender		Mean BMI (kg/m^2)	Total
	Male	Female		
6	20	20	14.62	40
7	20	20	15.62	40
8	20	20	16.12	40
9	20	20	16.66	40
10	20	20	17.39	40
11	20	20	17.58	40
Total	120	120		240

BMI- Body mass index

Table 2 Normative data of foot posture scores measured by FPI-6.Descriptive Statistics was used to obtain the mean and median values of foot posture scores. Females from age group 6 and 9 years had high mean value in FPI-6 scores.

Table 2: Normative data of foot posture scores measured by FPI-6

	Age (yrs)	Sex	N	Mean & SD	Median 50^{th} percentile	25^{th} percentile	75^{th} percentile
	6	M F	20 20	2.85 ± 2.720 3.00 ± 2.492	2.00 2.50	0.25 1.00	5.75 5.00

Right FPI score	7	M F	20 20	2.10 ± 2.936 1.20 ± 1.642	2.00 1.00	1.00 0.00	4.00 2.00
	8	M F	20 20	1.80 ± 3.473 1.55 ± 3.052	2.00 1.00	0.00 0.00	4.75 3.75
	9	M F	20 20	0.65 ± 2.084 2.85 ± 3.216	0.00 2.00	-0.75 0.00	2.50 5.00
	10	M F	20 20	1.70 ± 2.598 1.15 ± 3.856	1.50 0.50	0.00 -0.75	3.75 4.00
	11	M F	20 20	1.25 ± 2.049 1.20 ± 2.745	0.50 0.50	0.00 0.00	3.00 2.00
Left FPI score	6	M F	20 20	2.90 ± 2.198 3.00 ± 2.471	3.00 2.50	1.00 0.25	4.75 5.00
	7	M F	20 20	2.45 ± 3.18 1.85 ± 2.059	2.00 1.50	0.00 0.00	4.00 3.00
	8	M F	20 20	1.70 ± 2.319 1.40 ± 2.817	2.00 1.00	0.00 -0.75	3.00 3.00
	9	M F	20 20	0.70 ± 2.155 2.10 ± 3.307	0.00 1.50	-0.75 0.00	1.75 3.75
	10	M F	20 20	1.45 ± 2.819 0.85 ± 4.522	1.50 1.50	0.00 -0.75	4.00 4.50
	11	M F	20 20	1.20 ± 2.118 1.65 ± 2.581	1.00 1.00	0.00 0.00	3.00 3.00

Table 3 Results obtained from the association between age and foot posture showed that children of age 6 have a significant association with FPI-6, with $p<0.05$.

Table 3: Association of FPI-6 score with age

Age (yrs)	N	Kruskal Wallis Value		P Value	
		R	L	R	L
6	40	11.64*	11.868*	0.042*	0.037*
7	40	NS	NS	NS	NS
8	40	NS	NS	NS	NS
9	40	NS	NS	NS	NS
10	40	NS	NS	NS	NS
11	40	NS	NS	NS	NS

N- Total number of subjects, R- Right, L- Left, NS- Non significant *****-sig

Table 4 Association of FPI-6 with gender. Results obtained from the association between gender and foot posture score showed that children of age 9 have a significant association with FPI-6, with $p<0.05$.

Table 4: Association of foot posture score with gender

	Age (yrs)	Sex	N	Mannwhitney test Z value	P value
Right FPI scores	6	M F	20 20	0.26	0.795
	7	M F	20 20	1.62	0.106
	8	M F	20 20	0.46	0.643
	9	M F	20 20	2.44	0.015*
	10	M F	20 20	0.56	0.575
	11	M F	20 20	0.03	0.978
	6	M F	20 20	0.04	0.967
	7	M F	20 20	0.52	0.603
	8	M F	20 20	0.78	0.436

Left FPI scores	9	M F	20 20	1.41	0.158
	10	M F	20 20	0.16	0.870
	11	M F	20 20	0.49	0.621

FPI- Foot Posture Index, M- Male, F- Female, N- Total number of subject *-sig

Table 5 Normative data of types of foot postures using FPI-6. 75% males were found to have a normal foot and 73% females have normal foot posture.13%males have a supinated foot and 13% females have a pronated Foot. None of the children found to have a High Supinated or High Pronated foot.

TABLE 5: Normative data of types of foot postures using FPI-6

Gender	Foot types	6 yrs		7 yrs		8 yrs		9 yrs		10 yrs		11 yrs		Total
		R	L	R	L	R	L	R	L	R	L	R	L	
M	HS	0	0	1	0	1	0	0	0	1	1	0	0	4
	S	1	1	1	2	2	2	5	5	1	3	3	4	30
	N	14	14	16	16	14	18	14	14	17	15	16	16	184
	P	5	5	2	2	3	0	1	1	1	1	1	0	24
	HP	0	0	0	0	0	0	0	0	0	0	0	0	0
F	HS	0	0	0	0	1	0	0	0	1	3	0	0	5
	S	0	0	2	1	3	5	1	4	4	2	3	2	27
	N	16	16	18	18	13	13	15	13	13	11	15	15	176
	P	4	4	0	1	3	2	4	3	2	4	2	3	32
	HP	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		40	40	40	40	40	40	40	40	40	40	40	40	

HS- Highly supinated, S- Supinated, N- Normal, HP- Highly pronated, P- Pronated,

M- Male, F- Female, R- Right, L- Left

Table 6 Correlation between anthropometric parameters and foot types. Results have found that there was no correlation between anthropometric parameters and foot types.

Table 6: Correlation between anthropometric parameters and foot types

Anthropometric parameters	Rt foot types		Lt foot types	
	Spearman correlation coefficient	P value	Spearman correlation coefficient	P value
Height (m)	-0.155	0.064	-0.156	0.066
Weight (kg)	-0.047	0.472	-0.060	0.354
BMI (kg/m^2)	0.031	0.630	0.039	0.552

Ht- Height, Wt- Weight, BMI- Body mass index, Rt- Right, Lt- Left

Discussion

Understanding foot posture in typically developing children helps to detect any persistence of deviations beyond a certain stage of development, and also to provide scope for timely intervention to prevent any possible deformities and dysfunctions. The aim of the present study was to establish the normative data for Foot Posture Index in school-going children (aged from 6 to11 years) in Mangalore and the correlation of the FPI with age and gender. A further aim was to quantify the types of foot posture using FPI-6 scores and to determine the correlation of scores with anthropometry.

In the demographic data, height, weight and BMI of 95 % subjects in respective age groups were in agreement with Indian population [23]. Age had a significant effect on all six components of FPI-6 scores which were measured in males and females in the age groups of 6-11 years. In the age group of six, the median values of FPI-6 scores were in the higher range compared to those of the other groups. The present findings of higher score values in the age group of 6 years may be due to increased ligamentous laxity in children below 7 years of age, as reported in other studies by Ferciot and Falotico et al [24,25]. The present findings of higher score values in females may be due to increased incidence of ligamentous laxity in females, as reported in earlier by Jansson et al [26].

In the current study, significant association was found between foot posture scores (FPI-6) and gender in the age group of 9 years. Results of this study similar to the findings of a previous studies done by Eluwa et al and Didia et al [27,28]. The results of the present study depict a significance difference in foot postures in children aged 6 years as compared to older children. Prevalence of pronated feet was more common in 6-year old children. The findings of the present study can be attributed to the process of development of the medial longitudinal arch in children, which was also reported by a previous study done by Staheli et al

[29]. These findings are also supported by a study carried out by Redmond et al14 who had analysed foot postures in 225 children aged 3-11 years using FPI-6. They reported a high prevalence of pronated feet among children. No correlation was found between anthropometric parameters and foot types in the above-mentioned age groups. The results of the correlation between BMI and foot types are supported by a study carried out by Evans et al [30] in 140 school children.

The present study has many limitations (1) Normative data of FPI-6 obtained in the present study may not be generalized to include all Indian children (2) Presence of fat pads and soft tissue dispersion which may contribute to lower score in the medial longitudinal arch height in children's feet during double-limb supported stance, was not taken into consideration during the scoring procedure (3) Relationship between leg dominance and foot posture was not addressed. Also further studies can be carried out in order to correlate the normative values of Foot Posture Index scores with deviated foot types evaluated by radiographs as well as by comparing the foot posture between obese and non-obese children and in pathological conditions using FPI-6.

Clinical Implications

The present study established normative data of FPI-6 in children aged 6-11 years. The normative data developed in the present study can be used as baseline data for comparing the deviations seen in children with impaired foot posture. These values can also be used to monitor the outcome of the rehabilitation process in foot impairments.

Conclusion

The normative data of Foot Posture Index for children from 6-11 years of age was established in the present study. Age has a significant correlation with foot posture scores while gender and anthropometric parameters do not show any association with the scores.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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AUTHOR(S):

*Associate Professor, Department of Physiotherapy, Kasturba Medical College, Manipal University, Mangalore, Karnataka, India-575004.
**Assistant Professor, Program of Physical Therapy, Department of Medical Rehabilitation Sciences, College of Applied Medical Sciences, King Khalid University, Abha, Kingdom of Saudi Arabia.
Professor and Head, Department of Physiotherapy, Kasturba Medical College, Manipal University, Mangalore, Karnataka, India-575004.

CORRESPONDING AUTHOR:
Vijaya kumar K. Associate Professor, Department of Physiotherapy, Centre for Basic Sciences, KMC Bejai, Mangalore, Karnataka- 575004, India. Email: vijay.kk@manipal.edu ; vijaykmcmangalore@gmail.com

Conflict of Interest: None