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Research Article

Etiological Factors Affecting Development of Flat Foot - A Cross Sectional Study in Eastern India

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Abstract

Background: Flat foot is one of the most common pediatric foot problems that constitute 90% of clinic visits by parents. A number of factors have been attributed for development of this foot deformity. Controversies exist about their clinical significance and thus the management. However, without fully understanding the etiology, it is unclear that which approach is most appropriate for the management of flat foot.

Objective: To assess the role of potential etiological factors of flat foot like BMI, hyper mobility of joints, subtalar morphology and their correlation with development of flat foot measured with Arch Height Index.

Methods: As per calculated sample size, 35 participants conforming to inclusion criteria were included in the study. The study variables used for analysis were age, gender, Body Mass Index (BMI), Arch height Index (AHI), Lower Limb Assessment Scale (LLAS), subtalar joint morphology, Meary's angle, tibialis posterior muscle power, and tarsal coalition.

Results: There was no significant association between the flexibility of foot with age and BMI (p=0.326 & p =0.776 respectively). Age had an insignificant positive correlation with AHI and BMI had negative insignificant correlation with AHI. MRI study of foot in all cases showed presence of anterior facet in subtalar joint.

Conclusion: Out of all etiological factors, this study supports only the ligament laxity to be a possible etiological factor for the development of flat foot. Treatment strategy must address it for better outcome.

Keywords: Flat foot; Body mass index; Arch height index; Hyper mobile foot; Subtalar joint

Introduction

Flat foot is one of the most common pediatric foot problems that constitute 90% of clinic visits by parents [1]. It is considered as physiological in neonates and toddlers. A fat pad is present underneath the Medial Longitudinal Arch (MLA) of the infant's foot while the arch develops. Almost all children are flat-footed when they start walking [2]. As the arch of the foot is developed, the fat pad gradually resolves by 2-5 years of age. In about 3% of children, the foot arch might not develop even to skeletal maturity [2-4]. The prevalence of flat foot varies with age, race, gender, and obesity [5], and estimated to be present up to 20% of children and adolescents [6]. The incidence of flat foot is higher in blacks than in Caucasians. The correlation between gender and the flat foot is unclear. Some studies showed flat foot to be more prevalent in males [5], whereas others did not [7]. The essential functions foots are shock absorption, weight transmission and provide a stable platform that can adopt ground during the stance phase, at the same time it converts to a rigid lever to propel the body during push-off.

Flat foot can be divided into flexible and rigid categories. Rigid flatfoot is characterized by rigid flattened arch both in weight-bearing and swing phase most rigid feet are associated with the presence of calcaneonavicular bar and Talocalcaneal Bridge. Flexible flat foot present with a normal arch during non weight-bearing swing phase which flattened on stance. Initially, it was thought that medial longitudinal arch is formed due to muscular support to the bones of the medial arch but later on electromyography proved that no role of muscle in arch formation in standing position. A static arch is formed and maintained by ligaments and bones only [8]. Now it has been observed that intrinsic muscles of the foot, tibialis posterior muscle contributes significantly to the dynamic function of the foot [9,10]. Plantar fascia and spring ligament plays a pivotal role in maintaining of the longitudinal arch [11]. Other conditions frequently associated with flat foot include generalized ligamental laxicity, neurologic and muscular abnormalities, genetic conditions and collagen disorders. Morphological variation of the subtalar joint is possible with the presence or absence of anterior facet or fusion of middle and posterior facet [12]. The anterior facet of os calcis forms acetabulum pedis which is an important part supporting the talar head. The absence of this articulation could lead to a flat foot posture [6]. Accessory navicular providing anomalous insertion to tibial posterior contributes to flat foot has been shown to have not associated with the height of the medial longitudinal arch [13]. Looking towards the number of

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aetiological factors associated with flat foot, controversies exist about their clinical significance and thus the management. However, without fully understanding the etiology, it is unclear that which approach is most appropriate for the management of flat foot.

The aim of this study was to assess the role of potential aetiological factors of flat foot like BMI, hypermobility of joints, subtalar morphology and their correlation with Arch Height Index, Meary's angle & posterior tibial dysfunction.

Materials and Methods

This is an observational cross-sectional study conducted in a national rehabilitation institute of India. All the children with flat foot deformity reported by their parents to the outpatient department from 1st August 2017 to 30th April 2019 were recruited for the study. Inclusion criteria include children with flexible FF within 8 to 15 years age group, and children whose parent given consent to participate in the study. Children with neurological disease involving foot & ankle, any surgery at the spine or foot, and concurrent use of any foot orthosis were excluded from the study. The study variables used for analysis were age, gender, Body Mass Index (BMI), Arch Height Index (AHI), Lower Limb Assessment Scale (LLAS), subtalar joint morphology, Meary's angle, tibialis posterior muscle power, and tarsal coalition.

Children confirming to study criteria were assessed clinically and radiologically. A detail medical examination was done to assess foot posture, generalized ligamental laxicity, malalignment at proximal joints. Weight and height were measured to calculate Body Mass Index. Normal BMI was defined as <25kg/m^2, overweight was 25 kg/ m^2 to 30kg/ m^2 and obese was >30kg/m^2. AHI described by Williams and Mc Clay is the ratio of standing arch dorsal height as measured at 50%-foot length divided by truncated foot length (distance from posterior heel to 1st metatarsal head measured on the medial border of the foot without toes). These measures excellent inter and intraobserver reliability with well-established validity and reliability by Butler [14]. AHI of <0.31is considered as low arch, 0.31-0.37 as neutral and >0.37 as high arch. Generalized ligamental laxicity as flexibility at hip, knee, foot, and ankle joint was assessed using LLAS. Each limb was assessed and calculated separately giving a left and right LLA score. The maximum score for each limb is 12 and a score of 7 out of 12 is cut off for hypermobile joints [15]. MRC grading was used for the tibialis posterior muscle power assessment. Tarsal coalition & Subtalar joint morphology was studied from MRI of foot and anterior facet was assessed as per Brukner's classification [12]. Meary's angle was measured from a lateral weight-bearing radiograph of the foot and ankle.

At the end of the study, the data collected from the study were tabulated and analyzed accordingly. All the data were entered in Excel sheet and data analysis was performed using SPSS software 21.0 version (IBM corp. Armonk, NY, United States).

Sample size calculation

The study of Spahn et al. [16], over 2368 adolescents, observed the prevalence of flexible flat foot was 6.2%. Taking this value as reference, the minimum required sample size with 8% margin of error and 5% level of significance, came out as 35.

Statistical analysis

The normality of the data was tested with the Kolmogorov-Smirnov test. On rejection of the normality of the data, the non-parametric test was used. Pearson correlation coefficient/ spearman rank correlation coefficient was used to correlate parameters with AHI. Univariate and multivariate linear regression was used to assess the predictors of AHI. A p-value of <0.05 considered statistically significant.

Results

As per sample size calculation, 35 participants included in the study, 24(69%) were male & 11(31%) female. 13(37.14%) cases were of 8-10 years group, and 22(62.86%) of 11-15 years group with a mean age of 11.83(SD=2.42). Distribution of BMI among all 35 participants showed, 28(80%) cases within normal BMI and 2(5.71%) cases in underweight and 5(14.29%) cases were falling in overweight of BMI category (χ^2=0.697, p=0.706). AHI of all 35 cases on booth foot was falling under low arch level with mean AHI of left and right side 0.22(SD=0.03) & 0.22(SD=0.02) respectively. As per LLAS, 23(65.71%) cases had hypermobile foot and 12(34.29%) cases of the non-hypermobile foot. Mean LLA scores of right and left feet were 8.37(SD=2.95) and 8.17(SD=3) respectively. The mean value of Meary's angle measured in MRI was 21.06(SD=2.36). Subtalar morphology on MRI showed a presence of anterior facet in all the participants. Normal Tibialis posterior muscle power of 5/5 was observed bilaterally in all the cases. All the above data has been depicted in Table 1. None of the cases showed a tarsal coalition in their MRI study. There was no significant association between the flexibility of foot with age and BMI (Table 2). Table 3 shows the correlation of age and BMI with AHI(Lt), AHI(Rt), LLAS(Lt), LLAS(Rt) and Meary's angle in MRI respectively. It was found that age had an insignificant positive correlation with AHI and Meary's angle and a negative insignificant correlation with LLAS of both sides. BMI had a positive insignificant correlation with LLAS and a negative insignificant correlation with AHI of both side and Meary's angle. Hence age and obesities are not an aetiological factor for the development of FF. Therefore, there is no statistically significant difference in clinical outcome based on Age, Gender, AHI, subtalar joint morphology or flexibility score (LLAS).

Discussion

On review of literature, it is revealed that there is a wide variation in aetiological factors associated with flat foot. The prevalence, and its association with age, gender, body weight, BMI has been studied extensively by a number of authors [5,17-20]. Janckowicz et al. [21] in their study found that BMI is significantly correlated with the height of the foot arch but their age did not. Whereas the study of Jolanta et al. [19] shows arch height increased as age increased in both boys and girls with a significant increase of arch height in boys at 12-15 years and in girls at 10-15 years.The current study did not find any significant association of flat foot with age, body weight, and BMI. A similar result has been shown by Atamturk et al. [20]. The reliability of AHI as a measure of foot structure in children has been studied by Drefus et al. [22] & Rethlefsen et al. [23]. The presence of accessory navicular in FF affecting AHI has been discarded by the study of Kanatli et al. [13]. Wearing et al found a positive relationship with

Table 1: Table depicting data of various outcome parameters (n=35).

	Mean ± SD	Median	Min - Max	Inter Quartile Range
Age	11.83 ± 2.42	12	8 - 15	10 - 14
AHI[1](Lt)	0.22 ± 0.03	0.23	0.17 - 0.27	0.210 - 0.240
AHI(Rt)	0.22 ± 0.02	0.23	0.18 - 0.27	0.210 - 0.240
BMI[2]	22.35 ± 2.76	22.2	18.3 - 29.6	20.325 - 23.475
LLAS[3](Lt)	8.17 ± 3	9	3 - 12	5 - 10.750
LLAS(Rt)	8.37 ± 2.95	9	3 - 12	5 - 10.750
Meary's Angle	21.06 ± 2.36	21	16 - 25	19.250 - 23

[1]AHI: Arch Height Index; [2]BMI: Body Mass Index; [3]LLAS: Lower Limb Assessment Score

Table 2: Correlation of age & BMI with flexibility of foot (n=35).

	Hyper mobile foot (n=23)	Non-hypermobile foot (n=12)	p value
Age			0.326
Mean ± SD	11.56 ± 2.31	12.33 ± 2.64	
Median	12	12.5	
Range	8 -15	9 - 15	
Inter Quartile range	10 - 13.750	9.500 - 15	
BMI			0.776
Mean ± SD	22.44 ± 2.73	22.16 ± 2.91	
Median	22.2	21.5	
Range	18.4 - 28.5	18.3 - 29.6	
Inter Quartile range	20.350 - 23.550	20.350 - 23.450	

Table 3: Co-relation of Age & BMI with other parameters (n=35).

		AHI(Lt)	AHI(Rt)	LLAS(Lt)	LLAS(Rt)	Meary's Angle
Age	Correlation coefficient	0.241	0.105	-0.048	-0.081	0.31
	p value	0.163	0.5483	0.7823	0.6418	0.0695
BMI	Correlation coefficient	-0.194	-0.207	0.094	0.061	-0.049
	p value	0,2639	0.2323	0.5902	0.7271	0.7809

AHI: Arch Height Index; BMI: Body Mass Index; LLAS: Lower Limb Assessment Score

body composition and overweight on the arch index which in turn is influenced by arch flexibility from the hypermobile foot [24]. In the current study all the participants had a low arch index and out of that 65.7% had hypermobile foot with LLA score >7, which shows a positive association with AHI. However, LLAS, which suggests the ligamental laxicity of flat foot, did not show any correlation with age and BMI. These findings confirm with the study result of Kothari et al. [6] except the feeding of subtalar morphology. Anterior facet absent of subtalar joint in their study contributing to FF is not seen in our study rather all our patients had anterior facet in their MRI study. Posterior tibial tendon dysfunction, which is a part of the adult acquired flat foot is not seen in our study. All the cases had bilateral tibialis posterior normal muscle power.

Limitations of the study

Our study has some limitations to acknowledge. Sample size and a short study period is the major limitation of this study. The mean BMI of our cases was 22. The result would have been different if more cases of higher BMI were included. 3D reconstruction CT is the best for subtalar joint morphology but due to ionizing radiation, it was replaced by MRI which is a safe modality for growing skeleton.

Conclusion

Many etiological factors of flatfoot like age, sex, BMI, ligament laxity and absence of anterior facet of the subtalar joint have been studied previously but in this study age, BMI, subtalar joint morphology did not find to be related to flexible flatfoot. This study supports only ligament laxity to be a possible etiological factor for the flexible flatfoot. Further study is required to clarify the relation between ligament laxity and the development of flatfoot posture and symptoms related to it. Currently, no surgical treatment related to progressive flat foot deformity is oriented to ligament laxity. Further studies are required to carry out on new surgical procedures addressing flexibility of foot resulting from ligamental laxicity.

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