

THE INFLUENCE OF FOOTWEAR ON THE PREVALENCE OF FLAT FOOT

A SURVEY OF 1846 SKELETALLY MATURE PERSONS

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We analysed the static footprints of 1846 skeletally mature individuals to establish the influence of the age at which shoe-wearing began on the prevalence of flat foot.

The incidence was 3.24% among those who started to wear shoes before the age of six years, 3.27% in those who began between the ages of 6 and 15 and 1.75% in those who first wore shoes at the age of 16 ($p < 0.001$).

Flat foot was highest in those who, as children, wore footwear for over eight hours each day. Obese individuals and those with ligament laxity had a higher prevalence of flat foot ($p < 0.01$ and $p < 0.0001$, respectively). Even after adjusting for these two variables, significantly higher rates of prevalence were noted among those who began to wear shoes before the age of six years.

Our findings suggest an association between the wearing of shoes in early childhood and flat foot.

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Until recently it was believed that wearing shoes did not predispose to flat foot (Kelsey 1982). Rao and Joseph (1992), however, in a survey of schoolchildren showed a significantly higher prevalence of flat foot among those who wore shoes, suggesting that shoe-wearing may be detrimental to the development of a normal medial longitudinal arch.

The critical age for the development of the longitudinal arch is before six years (Rose, Welton and Marshall 1985). If wearing shoes does contribute to failure of development of the arch, the age at which it begins should influence the

onset of flat foot. Shoe-wearing before the age of six would predispose to flat foot whereas if it were delayed until the child was older, the propensity for flat foot would be less.

Our aim was to assess whether the prevalence of flat foot in a skeletally mature population was influenced by the age at which shoe-wearing began.

MATERIALS AND METHODS

Our survey included 1846 subjects over the age of 16 years of south Indian origin (Dravidian) from the Dakshina Karnataka District of Karnataka State comprising the entire staff of all the non-clinical departments of the Kasturba Medical College, Manipal (500), the entire staff of the Syndicate Bank, Head Office, Manipal (565), all the students of the Science Section of St Aloysius College, Mangalore (671) and all the students of the Arts Section of the Mahatma Gandhi Memorial College, Udipi (110). All were using some form of footwear at the time of the survey. The mean age of the population screened was 28.84 years (16 to 65).

The assessment of the foot forms was based on the classification of static footprints obtained using the differential pressure footprint map of Harris and Beath (1947). The technique of obtaining the footprints and their classification into normal, high-arched or flat have already been described (Rao and Joseph 1992).

The height, weight and the duration for which the subject had to stand or walk per day during the course of his job were recorded. The Body Mass Index (BMI) was calculated for each subject and the presence of ligament laxity was noted as described by Rao and Joseph (1992). The age at which shoes were first worn was recorded. We also noted the type of footwear used, the duration of wearing shoes each day currently and at the time of starting shoe-wearing and whether shoes were worn outdoors only or both indoors and outdoors.

None of the subjects knew that the study was to assess the prevalence of flat foot. The information regarding shoe-wearing habits was initially recorded from all the subjects screened on each day. The footprints were then obtained and analysis of these was done later by the same investigator (VS). At the time of the foot-print analysis the questionnaire pertaining to shoe-wearing practice was not available thereby minimising the risk of bias.

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Twenty-four footprints were analysed on two separate occasions, one week apart and classified by the same investigator. The results of the two assessments were compared to measure intraobserver reliability. The difference in measurements of the arch width was plotted against the mean values of each foot. The standard deviation of the differences between the two measurements and the coefficient of repeatability (Bland and Altman 1986) were calculated.

RESULTS

Of the 1846 subjects screened 54 (2.9%) had flat feet, 193 (10.5%) had a high arch and 1599 (86.6%) had normal feet.

The prevalence of flat foot in those who started using footwear before the age of five years was 3.24% (30/926); it was 3.27% (17/520) in those who began between the ages of 6 and 15 years and 1.75% (7/400) in those who first used shoes after the age of 16 years ($p < 0.001$; Table I).

The age of the subjects at the time of screening and the duration for which they had to stand or walk during their current occupation had no bearing on the prevalence of flat foot (Tables II and III).

Of the subjects who wore shoes before the age of six years those who used them for longer than eight hours each day in early childhood had a significantly higher prevalence of flat foot than those who wore them for shorter periods ($p < 0.05$). Subjects who wore slippers or sandals before six years of age had a lower prevalence than those who used closed-toe shoes, but this difference was not statistically significant (Tables IV and V).

Subjects with ligament laxity and obese subjects had a significantly higher prevalence of flat foot (Tables VI and VII).

All the 24 feet included in the reproducibility study were assessed as having the same footprint type (i.e., normal, flat or high-arched) on both occasions. The difference between the measurements of arch width made on the two occasions was assessed against the mean. The mean difference in measurements of arch width was 0.21 mm and the standard deviation was 2.75 mm. The coefficient of repeatability was 5.5 mm.

DISCUSSION

We observed no difference in the prevalence of flat foot in the various age groups screened, indicating that significant variations in prevalence do not occur with increasing age after skeletal maturity. This is in contrast to children in whom the prevalence decreases with increasing age (Morley 1957; Rao and Joseph 1992). We did not therefore consider age to be a variable in this study.

The length of time for which the subjects stood during the course of their work had no bearing on the prevalence of flat foot, suggesting that prolonged weight-bearing is

Table I. Relationship between the age at which shoes were first worn and the type of footprint, by number and *percentage*

Age when shoes first worn (yr)	Footprint type		
	Normal	High arch	Flat foot
1 to 5 (n = 926)	825 (89.10)	71 (7.67)	30 (3.24)
6 to 15 (n = 520)	440 (84.62)	63 (12.12)	17 (3.27)
> 16 (n = 400)	334 (83.50)	59 (14.75)	7 (1.75)*

* $p < 0.001$

Table II. Relationship between the age of the subjects and the type of footprint, by number and *percentage*

Age (yr)	Footprint type		
	Normal	High arch	Flat foot
16 to 25 (n = 945)	834 (88.25)	82 (8.68)	29 (3.07)
26 to 35 (n = 315)	274 (86.98)	33 (10.48)	8 (2.54)
36 to 45 (n = 408)	346 (84.80)	51 (12.50)	11 (2.70)
46 to 55 (n = 157)	127 (80.89)	25 (15.92)	5 (3.18)
> 56 (n = 21)	18 (85.71)	2 (9.52)	1 (4.76)

Table III. Relationship between the duration of walking or standing each day in the current job and the prevalence of flat foot, by number and *percentage*

Duration of walking/standing (hr)	Footprint type		
	Normal	High arch	Flat foot
< 2 (n = 801)	677 (84.52)	101 (12.61)	23 (2.87)
2 to 4 (n = 472)	421 (89.19)	37 (7.84)	14 (2.97)
4 to 6 (n = 250)	221 (88.40)	24 (9.60)	5 (2.00)
> 6 (n = 323)	280 (86.69)	31 (9.60)	12 (3.72)

Table IV. Relationship between the duration of wearing shoes each day before six years of age and the prevalence of flat foot in 926 subjects, by number and *percentage*

Use of footwear (hr/day)	Footprint type		
	Normal	High arch	Flat foot
< 8 (n = 734)	665 (90.60)	50 (6.81)	19 (2.59)
> 8 (n = 192)	161 (83.85)	20 (10.42)	11 (5.73)*

* $p < 0.05$

Table V. Relationship between the type of footwear used before the age of six years and the prevalence of flat foot in 926 adults, by number and *percentage*

Type of footwear	Footprint type		
	Normal	High arch	Flat foot
Slippers and sandals (n = 565)	501 (88.67)	49 (8.67)	15 (2.65)
Closed-toe shoes (n = 361)	325 (90.03)	21 (5.82)	15 (4.15)

Table VI. Relationship between lax ligaments and the prevalence of flat foot in 1846 subjects as percentage

	Footprint type		
	Normal	High arch	Flat foot
Lax ligaments (n = 113)	83.19	7.08	9.73*
Normal ligaments (n = 1733)	86.84	10.68	2.48

* p < 0.0001

Table VII. Relationship between obesity and the prevalence of flatfoot in 1846 subjects, as percentage

Body Mass Index*	Footprint type		
	Normal	High arch	Flat foot
< 24 (n = 1505)	86.44	11.09	2.48
≥ 24 (n = 341)	87.39	7.62	4.99†

* BMI value of ≥ 24 indicates obesity (Bray, Jordan and Sims 1976)

† p < 0.01

Table VIII. Number and percentage of normal, high-arched and flat feet in 1846 subjects with and without generalised ligament laxity who began to wear shoes at different ages

	Age at which shoes were first worn (yr)	Footprint type			p value
		Normal	High arch	Flat foot	
Lax ligaments	≤ 5 (n = 67)	57 (85.07)	2 (2.99)	8 (11.94)	
	6 to 15 (n = 27)	22 (81.48)	3 (11.11)	2 (7.41)	NS
	≥ 16 (n = 19)	15 (78.95)	3 (15.79)	1 (5.26)	
Normal ligaments	≤ 5 (n = 859)	768 (89.41)	69 (8.03)	22 (2.56)	
	6 to 15 (n = 493)	418 (84.79)	60 (12.17)	15 (3.04)	< 0.01
	≥ 16 (n = 381)	319 (83.73)	56 (14.70)	6 (1.57)	

Table IX. Number and percentage of normal, high-arched and flat feet in 1846 obese and non-obese subjects who began to wear shoes at different ages

	Age at which shoes were first worn (yr)	Footprint type			p value
		Normal	High arch	Flat foot	
Non-obese (BMI < 24)	≤ 5 (n = 803)	715 (89.04)	68 (8.46)	20 (2.49)	
	6 to 15 (n = 401)	335 (83.54)	52 (12.97)	14 (3.49)	0.01
	≥ 16 (n = 301)	251 (83.39)	47 (15.61)	3 (0.99)	
Obese (BMI ≥ 24)	≤ 5 (n = 123)	110 (89.43)	3 (2.44)	10 (8.13)	
	6 to 15 (n = 119)	105 (88.23)	11 (9.24)	3 (2.52)	0.05
	≥ 16 (n = 99)	83 (83.83)	12 (12.12)	4 (4.04)	

unlikely to cause flat foot. A higher prevalence was not observed in the older adults which indicates that it does not develop as a cumulative effect of weight-bearing.

The most important finding was the higher prevalence of flat foot among adults who began using footwear in early

childhood. Analysis of the data after adjusting for ligament laxity and obesity confirmed this observation (Tables VIII and IX). Although a statistically significant difference was not shown among those with lax ligaments (Table VIII), the trend of the highest prevalence of flat foot and the lowest prevalence of high-arched feet among early shoe-wearers is clearly seen. Rao and Joseph (1992) noted that in children under six years there was an appreciably higher prevalence of flat foot among those who wore shoes than in those who did not. They concluded that the possible deleterious effects of shoe-wearing were active at the critical age in the development of the medial longitudinal arch in these children. These observations and the results of the present study lend further support to Rose's hypothesis (Rose et al 1985) that the critical age for development of the arch is before six years.

Rao and Joseph (1992) had observed that whenever the prevalence of flat foot was low, that of high-arched feet was high. This was also seen in the present study which suggests that factors conducive to the development of the arch

lead to a low prevalence of flat foot and a high prevalence of high-arched feet and vice versa. We believe that it is necessary to assess the prevalence of both high-arched feet and flat feet when studying the factors which may influence the development of the medial longitudinal arch.

Sample selection in this study was particularly difficult as it was necessary to include adequate numbers of subjects with different shoe-wearing practices. The memory of wearing shoes in early childhood may be inaccurate, especially for the older subjects of the sample. Nevertheless, we believe that the responses of the subjects were accurate as virtually all seemed very sure about when they began to use footwear. In rural India, children start to wear shoes either on entering school at the age of five to six years or on leaving school either for a job or to enter college over 16 years of age. These significant stages of their lives are likely to be remembered clearly. As the subjects were unaware that the study was related to flat foot, their responses to questions pertaining to shoe-wearing would not be biased by the status of their arches, avoiding the risk of selective recall. Rao and Joseph (1992) had emphasised that awareness about flat foot is extremely low among the rural population of this region. This is pertinent, as the observation that the early use of footwear was more common among those with lax ligaments (Table VIII) cannot be explained on the basis of the individuals resorting to the early use of footwear because of incipient flat foot.

Our study supports our earlier impression that there is an association between shoe-wearing in early childhood and flat foot, but prospective longitudinal studies are needed to confirm these impressions and to establish a causal relationship.

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