Original Research Article

Prevalence of flat foot among medical students and its impact on quality of life and functionality

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ABSTRACT

Background: Flat foot also called pes planus/fallen arches is common deformity in adults. The present study was undertaken to investigate the prevalence of flat foot among medical students and to find out the association of flat foot with age, gender, body mass index (BMI), foot length and its impact on quality of life and functionality.
Methods: A total of 300 medical students of age group 17-23 years were investigated for the presence of flat foot by using navicular drop (ND) test, arch index (AI) and foot posture index (FPI). The data obtained was subjected to statistical analysis using SPSS software.
Results: Prevalence of bilateral flat foot was 11.6% (8.3% were females and 3.3% were males). Unilateral was 3% (2% were females and 1% were males) and the correlation of ND, AI, FPI with gender, age was not significant and with BMI, weight was highly significant.
Conclusions: Our study showed the presence of bilateral flat foot in 11.6% and unilateral in 3% students. Flat foot is associated with BMI, weight and slightly associated with foot length, height and it is not associated with age, gender. Flat foot effected the quality of life and functionality of the students whose BMI is more.

Keywords: Arch index, Flat foot, Foot posture index, Navicular drop test

INTRODUCTION

Pes planus/flat foot is one of the common conditions observed in adult health practice.[1] It is characterized by medial rotation and plantar flexion of the talus, eversion of the calcaneus, collapsed medial arch and abduction of the fore foot with the entire sole of the foot coming into complete or near complete contact with the ground depending on the degree of the disability.[2] Arches of foot rapidly develop between 2 to 6 years of age and become structurally mature around 12 to 13 years of age.[3] Flat foot has been associated to family history, use of foot wear in infancy, obesity and urban residence and it has also been associated with age, gender and foot length.[4] The medial longitudinal arch (MLA) of foot is higher than the lateral longitudinal arch (LLA) and its curvature flattens to variable degree during weight bearing.[5] The height of MLA is most important measurement in determining degree of Pes planus.[6] Due to baby fat, infants are born with flat foot. Later during adult hood, the longitudinal arch develops naturally. When the children begin to stand on their feet, flat foot becomes diagnosable. Flat foot has multiple etiologies and it may lead to pain in heel, knee, hip and the back. It may cause other problems such as bunions, hammer toes, and shin splints.[7] Some authors reported that the prevalence of flat foot in children is between 21% to 57%, the percentage has decreased to between 13.4% to 27.6% in primary school children.[8] The adult flat foot is often a complex disorder with adversity of symptoms and various degrees of deformity. Pathology and symptoms are caused by structural loading changes along the medial foot and

plantar arch, as well as by collapse through the mid foot and impingement along the lateral column and rear foot. Muscles in the leg and foot tend to fatigue and cramp because of overuse.[9]

The present study was undertaken to investigate the prevalence of flat foot among medical students with more reliable methods such as navicular drop test, arch index and foot posture index which have proven to be more valid and to find out the association of flat foot with age, gender, BMI, foot size and its impact on quality of life and functionality.

The findings of this study underscore the importance of screening and regular physical examination and monitoring of flat foot so as to engender early diagnosis and intervention strategies for high-risk flat foot.

METHODS

This cross-sectional study was conducted in ESIC Medical College, Sanath Nagar, Hyderabad. A total of 300 medical students participated in this study. The present study was carried out during the period from June 2019 to July 2019.

The ethical clearance was obtained from Institutional Ethical Committee (IEC). Written informed consent was obtained from all the students fitting in inclusion criteria. Students with lower extremity deformity, injury or neuro muscular disorder at the time of assessment was excluded from the study. Demographic data of each student such as name, age, gender, height, weight, BMI, foot length was assessed. Flat foot assessment was done by following methods: a) Navicular drop test, b) Arch index, c) Foot posture index (FPI).

Navicular drop test

Navicular drop (ND) was measured applying Brody method. Each subject was asked to sit in a relaxed position with their feet flat on a firm supporting surface and with the knees flexed to 90° and ankle and subtalar joints in neutral position. The most prominent point of the navicular tubercle while maintaining subtalar neutral position of the subject was identified and marked with a pen. An index card was placed on the inner aspect of the hind foot, with the card placed from the floor in a vertical position passing the navicular bone. The level of the most prominent point of the navicular tubercle was marked on the card. The subject was then asked to stand without changing the position of the feet and to distribute equal weight in both the feet. In the standing position, the most prominent point of the navicular tubercle relative to the floor was identified again and marked on the card. Then, the difference between the two points on the card (Navicular drop) was measured with a calibrated ruler in centimetres. Navicular drop was measured for both the feet in each subject.[10-12]

Arch index

For calculating arch index (AI), an inkpad was prepared using washable ink. Each subject was asked to place his/her feet first in the inkpad. Then two, centimetre calibrated graph sheets were provided and he/she was asked to place his/her left and right feet on separate graph sheets in weight bearing position so that they totally cover his/her foot. Thus, the standard imprint of the feet was taken. Using foot print method, a foot axis was drawn from the centre of heel to the tip of the second toe. Next a perpendicular line was drawn tangential to most anterior point of the main body of the foot print and its point of intersection on foot axis was marked. Then the line between the point of intersection and the centre of the heel is divided into three equal parts. Ultimately the main body of the footprint was divided into three parts i.e. anterior, middle and posterior respectively and their areas were calculated in sq.cm. Then AI was calculated for both the feet as the ratio of area of the middle part of main body of the foot print into the entire area of main body of the foot print.[13]

Foot posture index

For checking the foot posture index (FPI), the subject was asked to stand in relaxed, double limb stance position. Then his/her foot was observed in anterior, posterior, medial and lateral directions.

FPI of both the feet was assessed using the following six criteria: 1) Talar head position. 2) Supra and infra lateral malleolar curvature. 3) Calcaneal frontal plane position. 4) The bulge in the region of the talo-navicular joint. 5) The congruence of the medial longitudinal arch. 6) The extent of abduction/adduction of the forefoot on the rear foot.

After all the six observations were made, the subject's foot was given a grade in each of these positions. For each criterion, values of +1/+2 were given for a pronated position, values of -1/-2 are given for supinated position and zero was given for a neutral position and the final score which is in between -12 to +12 was calculated by adding the values of all the six criteria. The master chart was prepared using these scores.[14,15]

After obtaining this data the flat foot was graded in three grades: grade 1, grade 2 and grade 3 based on the Denis method.[16] The body mass index (BMI) of each student was calculated and classified into underweight, normal weight and overweight categories. Students with positive findings of flat foot was given a health questionnaire for assessing its impact on quality of life and functionality.

Statistical analysis

SPSS software was used for analysing the data. The navicular drop, arch index, foot posture index was compared among males and females. The navicular drop

>10 mm was considered as index for flat foot. The prevalence of flat foot was calculated separately for males and females, and also for entire study population. 'P' value of <0.05 was considered statistically significant. The correlation was done by using Spearman's correlation test.

RESULTS

A total of 300 medical students in the age group 17 to 23, were recruited for the present study.

Subjects were distributed according to age, gender, BMI.

According to gender

126 subjects were males and 174 subjects were females.

According to age

26 subjects were of 17 years old, 68 subjects were of 18 years old, 105 subjects were of 19 years old, 40 subjects were of 20 years old, 25 subjects were of 21 years old, 14 subjects were of 22 years old and 22 subjects were of 23 years old.

According to BMI

35 subjects were underweight, 193 subjects were having normal weight, 60 subjects were overweight, 12 subjects were having class I obesity as per WHO classification of BMI.

Distribution navicular drop score among the subjects

Figure 1 shows distribution of navicular drop test score (≥1 cm and <1cm) among the subjects. In that, 256 subjects (113 males and 143 females) were having ND<1 cm (normal foot) and 35 subjects (10 males and 25 females) were having ND≥1 cm (flat foot) for both the feet.
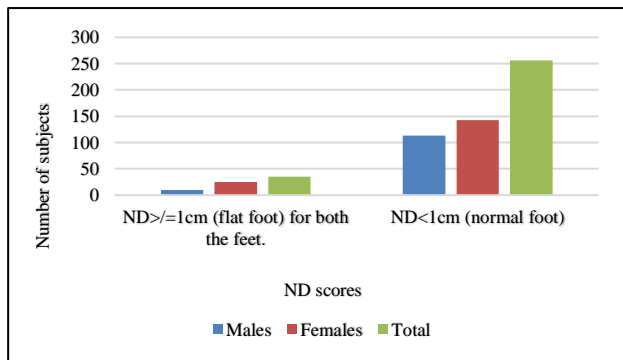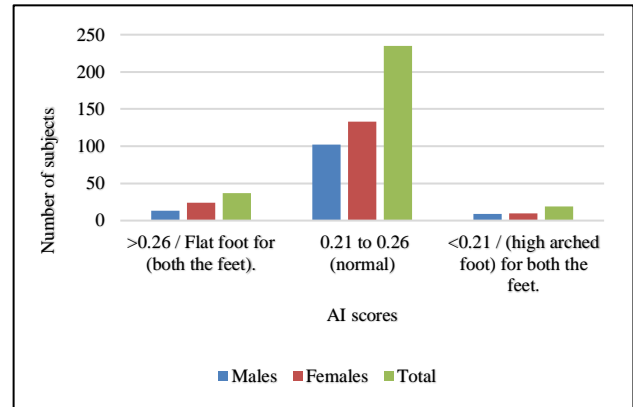

Figure 1: Distribution of ND score among the subjects.

Remaining 9 subjects (3 males and 6 females) were having ND>1 for only one feet (unilateral flat foot).

Distribution of arch index score among the subjects

Figure 2 shows distribution of arch index score [>0.26, of (0.21 to 0.26) and <0.21] among the subjects. In that, 235 subjects (102 males and 133 females) were having AI score of 0.21 to 0.26 (normal foot) for both the feet, 37 subjects (24 females and 13 males) were having AI>0.26 (flat foot) and 19 subjects (9 males and 10 females) were having AI<0.21 (high arched foot).
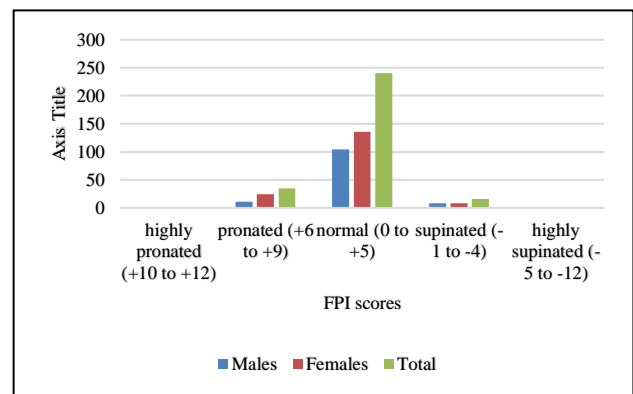

Figure 2: Distribution of AI score among the subjects.

Remaining 9 subjects (2 males and 7 females) were having AI>0.26 for only one foot (unilateral flat foot).

Distribution foot posture index score among the subjects

Figure 3 shows the distribution of foot posture index score among the subjects. In that, 240 subjects (104 males and 136 females) were having FPI score of 0 to +5 (normal), 35 subjects (11 males and 24 females) were having FPI score of +6 to +9 (pronated) for both the feet, 16 subjects (8 males and 8 females) were having FPI score of -1 to -4 (supinated) for both the feet, only 1 male subject was having FPI score of +10 to +12 (highly pronated) for both the feet and no one was having FPI score of -5 to -12 (highly supinated).


Figure 3: Distribution of FPI score among the subjects.

Remaining 8 subjects (2 males and 6 females) were having FPI score of +6 and +9 (pronated) for only one foot.

Grading of flat foot on the basis of Denis method by observing the foot prints of the subjects

Figure 4 shows the grading of flat foot on the basis of Denis method. In that, 10 subjects were having flat foot of grade-I, 19 subjects were having flat foot of grade-II, 8 subjects were having flat foot of grade-III.
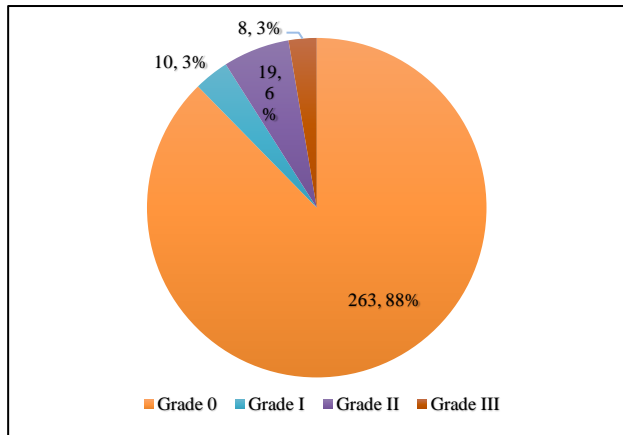
Figure 4: Grading of flat foot on the basis of Denis method.

263 subjects were having normal foot.

The correlation of navicular drop with age, gender, height, weight, BMI, foot length was evaluated using Spearman's test (Table 1).

Table 1: Correlation of ND with age, gender, height, weight, BMI, foot size.

	Correlation with	Spearman's rho	P value
Right ND	Age	-0.075	0.195
	Gender	0.057	0.327
	Height	0.128**	0.026
	Weight	0.354**	0.000
	BMI	0.380**	0.000
	Foot length	0.199**	0.001
Left ND	Age	-0.081	0.162
	Gender	-0.054	0.354
	Height	0.044	0.445
	Weight	0.247**	0.000
	BMI	0.305**	0.000
	Foot length	0.092	0.112

The correlation of the right ND and left ND with weight, BMI, was found to be highly significant. Correlation of right ND with height and foot length was significant. Correlation of right ND and left ND with age, gender was

not significant. Correlation of Left ND with height, foot length was also not significant.

The correlation of arch index with age, gender, height, weight, BMI, foot length was evaluated using Spearman's test (Table 2).

Table 2: Correlation of AI with age, gender, height, weight, BMI, foot size.

	Correlation with	Spearman's rho	P value
Right AI	Age	-0.081	0.161
	Gender	0.077	0.184
	Height	0.105	0.070
	Weight	0.237**	0.000
	BMI	0.259**	0.000
	Foot length	0.159**	0.006
Left AI	Age	-0.040	0.490
	Gender	-0.048	0.409
	Height	0.049	0.397
	Weight	0.227**	0.000
	BMI	0.268**	0.000
	Foot length	0.072	0.212

The correlation of the right AI and left AI with weight, BMI, was found to be highly significant. Correlation of right AI with foot length was significant. Correlation of left AI with foot length was not significant. Correlation of right AI and left AI with age, gender, height was not significant.

**Table 3: Correlation of FPI with age, gender, height, weight, BMI, foot size.**

	Correlation with	Spearman's rho	P value
Right FPI	Age	-0.017	0.775
	Gender	-0.006	0.914
	Height	0.074	0.201
	Weight	0.230**	0.000
	BMI	0.274**	0.000
	Foot length	0.063	0.280
Left FPI	Age	0.015	0.795
	Gender	-0.003	0.964
	Height	0.055	0.339
	Weight	0.223**	0.000
	BMI	0.266**	0.000
	Foot length	0.067	0.249

The correlation of foot posture index with age, gender, height, weight, BMI, foot length was evaluated using Spearman's test (Table 3).

The correlation of right FPI and left FPI with BMI, weight was found to be highly significant. Correlation of right FPI and left FPI with age, gender, height, foot length was not significant

The prevalence of flat foot among the subjects under study and its distribution according to gender

The subject is considered to have flat foot if the navicular drop is ≥1.
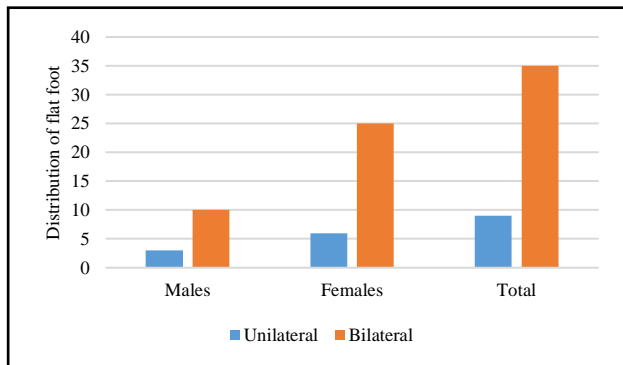
Figure 5: Prevalence of flat foot among the subjects and its distribution according to gender.

Figure 5 shows that, 35 (11.6%) subjects of the total study population were having bilateral flat foot and 9 (3%) of them were having unilateral flat foot. It also shows that, distribution of the bilateral and unilateral flat foot is more among females than in males.

Distribution of flat foot according to BMI

Figure 6 shows the distribution of flat foot among the study population according to the BMI.
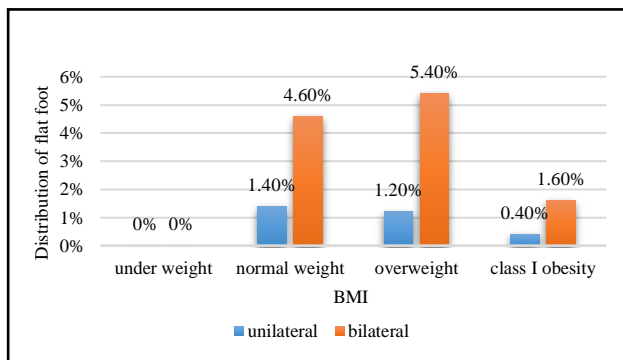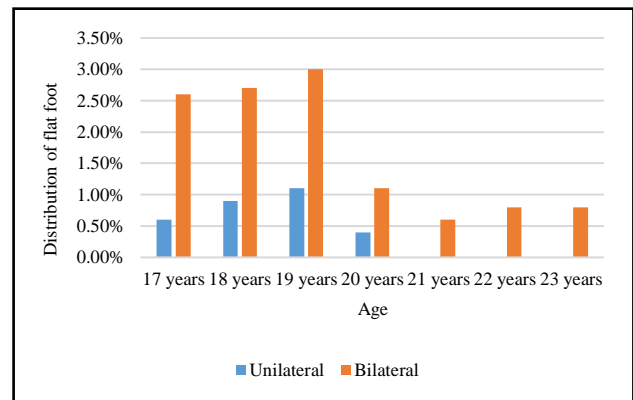

Figure 6: Distribution of flat foot according to BMI.

In that, distribution of flat was not found among the students with underweight. Students with normal weight were having 4.6% of flat foot bilaterally and 1.4% unilaterally. Students with overweight were having 5.4% of flat foot bilaterally and 1.2% unilaterally. Students with class I obesity were having 1.6% of flat foot bilaterally and 0.4% unilaterally.

Distribution of flat foot according to age

Figure 7 shows the distribution of flat foot according to age. In that, the students of 17 years old were having

2.6% of flat foot bilaterally and 0.6% unilaterally. 18 years old were having 2.7% of flat foot bilaterally and 0.9% unilaterally. 19 years old were having 3% of flat foot bilaterally and 1.1% unilaterally. 20 years old were having 1% of flat foot bilaterally and 0.4% unilaterally. 21 years old were having 0.3% of flat foot bilaterally. 22 and 23 years old were having 0.7% bilaterally.

Figure 7: Distribution of flat foot according to age.

DISCUSSION

Our study was to find out the prevalence of flat foot in a population of 17-23 years old medical students by navicular drop test, arch index and foot posture index.

The prevalence of bilateral flat foot among total study sample (300) was 11.6% (males- 3.3% and females- 8.3%).

The prevalence of bilateral flat foot as reported by some authors was 13.6% by Ashok et al, 5.2% by Arthi et al and 11.25% by Bhoir et al.[3,10,17] Inconsistence of values for flat foot prevalence among adult population can be attributed to the different sample size used by different authors.

Queen et al studied the correlation of footprint measurements to normalized navicular height ranged from 0.585 to 0.648.[18] Historically, the height of the navicular is considered to be the best approximation of medial longitudinal arch height. The results of this study indicate that the footprint indices are highly correlated with navicular height, indicating that both navicular height measurements and footprint measurements are valid measures of medial longitudinal arch height. Multiple methods exist for measuring the height of the medial longitudinal arch. Therefore, it is important to develop a standard set of measurements to be used when foot type is used as a variable in research studies or when making a clinical diagnosis. Nielsen et al, studied on 280 participants and stated that dynamic navicular drop is influenced by the foot length and gender and no significant effect was found of age (p=0.27) or BMI (p=0.88).[19]

According to Ashok et al (2017), the mean±SD of right ND (mm) was 0.67±0.42 and left ND (mm) was 0.69±0.42 and the correlation of right ND with height and weight was significant, but insignificant with BMI. The correlation of left ND with height, weight, BMI was not significant.[10]

Our result showed, the mean±SD of right ND (mm) was 0.74±0.25 and left ND (mm) was 0.69±0.24 and the correlation of the right ND and left ND with weight (p=0.00), BMI (p=0.00) was highly significant. Correlation of right ND with height (p=0.026) was also significant. Correlation of left ND with height was not significant, correlation of right and left ND with age was not significant.

Egwu et al reported the prevalence of flat foot among adult population in Anambra as 8.9% bilaterally and 5% unilaterally.[20] Pranathi et al has conducted a study on 50 adolescents aged between 14-20 years and reported the prevalence as 8% bilaterally and 6% unilaterally.[21]

Butler et al took measurements with the arch height index measurement system device exhibited high intrarater and interrater reliability. 'The mean±SD arch height index of the recreational runners was 0.340±0.030. Men had larger feet than women, but the arch height index between genders was similar'. The arch height index measurement system device is reliable to use between testers while simplifying the measurement procedure for recording the arch height index. The arch height index may be helpful in identifying potential structural factors that predispose individuals to lower-extremity injuries.[22]

According to Bhoir et al there was no correlation of arch index with BMI.[3]

Our result showed, the mean±SD cm value of right AI and left AI was 0.24±0.36 and correlation of the right AI and left AI with BMI (p=0.00), was found to be highly significant. The mean±SD cm value of right FPI was 2.19±2.5 and left FPI was 2.31±2.5 and correlation of the right FPI and left FPI with BMI (p=0.00), weight (p=0.00) was found to be highly significant and with age, gender, height, foot length was not significant.

Eluwa et al reported a flat foot incidence more in females than in males. The prevalence of flat foot was determined among the people of Akwa Ibom state of Southern Nigeria. The overall prevalence of flat foot was 13.4% with prevalence of 5.8% among males and 7.6% among females.[23]

Umar et al indicated that all the measured anthropometric foot parameters in their study showed that male subjects process higher tendency to develop flat foot than their female counter parts. They reported a flat foot incidence of 13% in males and 12% in females out of 200 Yoruba school students.[24]

According to Chang et al the incidence percentages of flat foot in a total sample of 1,222 among Taiwanese school aged children were 67% for males and 49% for females.[5]

Reihaneh et al confirmed that prevalence of flat foot in girls is slightly more than boys: 75.2% of girls and 72.6% of boys showed flat feet but without any significant statistical difference.[25]

There was no correlation of flat foot with gender and age according to our result. But flat foot prevalence was more among females and students with age group of 19 years. It might be due to difference in the sample size of males and females and also difference in the sample size of different age groups.

Impact of flat foot on quality of life and functionality

Many students were not aware that they have a flat foot before our study and they have no complaints of pain or any functional deformity.

Few students with overweight complained about history of pain and numbness on prolong standing like during the dissection hours and clinical postings.

While others complained about pain on wearing hard leather shoes and walking with slippers.

Limitations of the study are: our study was done only among the medical students, other population was not included in the study. Male and female sample size was not equal. Only the age group of 17-23 years was involved in the study. Foot print area was calculated manually on a graph paper which may lead to systematic error.

CONCLUSION

Based on the results and the methodology employed, we have concluded that:

In the present study on 300 medical students between the age group of 17-23 years, the prevalence of bilateral flat foot was 11.6% (8.3% were females and 3.3% were males). Unilateral was 3% (2% were females and 1% were males) and the correlation of ND, AI, FPI with gender was not significant. It shows that flat foot is not associated with gender.

According to age, the students of 17 years old were having 2.6% of flat foot bilaterally and 0.6% unilaterally. 18 years old were having 2.7% of flat foot bilaterally and 0.9% unilaterally. 19 years old were having 3% of flat foot bilaterally and 1.1% unilaterally. 20 years old were having 1% of flat foot bilaterally and 0.4% unilaterally. 21 years old were having 0.3% of flat foot bilaterally. 22 and 23 years old were having 0.7% bilaterally and the

correlation of the ND, AI and FPI with age was not significant. It shows that flat foot is not associated with the age.

According to BMI, flat foot was not found among the students with underweight. Students with normal weight were having 4.6% of flat foot bilaterally and 1.4% unilaterally. Students with overweight were having 5.4% of flat foot bilaterally and 1.2% unilaterally. Students with class I obesity were having 1.6% of flat foot bilaterally and 0.4% unilaterally. The correlation of the ND, AI, FPI with BMI, weight was highly significant. It shows that the flat foot is associated with BMI and weight.

Only the correlation of right ND and AI with foot length and height was significant so, flat foot may or may not be associated with foot length and height.

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