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Research Article

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Anthropometric Measurements Of The Medial Longitudinal Arch Of Foot In Male And Female Population With Its Clinical Correlation

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ARTICLE INFO	ABSTRACT

Background and Aim: The medial longitudinal arch is formed by specific structures that allow the foot to function effectively. The medial longitudinal arch is formed by two pillars, the anterior and posterior pillars.
Material and Methods: This cross-sectional, observational approach, the current study included 350 young Indian individuals between the ages of 17 and 40. The participants were chosen at random from north Gujarat area; there were 240 men and 110 women
Results: Very strong positive correlation was found between Foot Length and Height of individual for both feet which was statistically significant. Foot Length also showed strong positive correlation with Navicular drop of individual which were statistically significant. The correlation of Arch Height (AH) with demographic variables i.e. height and weight of individual were moderately positive, weak positive respectively.
Conclusion: Based on the result and the methodology employed , we have conducted that, in present study on 350 random population between the age group of 17to 35 years, the prevalence of unilateral flat foot 12.5 % (10% were males and 12.5% were females).

Keywords: Anthropometric Measurement, Arch Height, Arch Spread, Navicular drop

Introduction

The medial longitudinal arch is formed by specific structures that allow the foot to function effectively. The medial arch is compose of the first three metatarsal, three cuniform, navicular, talus and calcaneus bones of the foot. The calcaneus and talus articulate at the subtalar joint to form the hind foot.[1,2] The subtalar joint has three facetson both the calcaneusand the talus. The head of the talus is curved in convex cartilage and articulate with the navicular as the talus inferiorly and medially decends. A ball asocket joint are between the navicular and talus, with the proximal portion of the navicular forming a concave shape.[3,4]
The medial longitudinal arch is formed by two pillars, the anterior and posterior pillars. The medial three metatarsals heads comprises the anterior pillar, and the posterior pillar is made up of the tuberosity of the calcaneus. The peak of the medial arch is the superior articular surface of the talus.[5,6] The medial arch garners support from the planter calcaneonavicular ligament or spring ligament deltoid ligament (the tibio navicular portion, and anterior fibers), medial talocalcneal ligament, talocalnaeal interosseous ligament, posterior tibial tendon and planter aponeurosis. These structures stabilize the arch and midfoot.[7,8] Specially the spring ligament provide support for the head of the talus, and the planter aponeurosis act as a significant supporting structure between the two pillars of the medial arch. The spring ligament braces the joint between the talus

and the navicular, which is considering a weaker potion of the arch due to its exposure to over pressure. The spring ligament provides elasticity and allows the arch to remain its structure after the removal of the pressure.[9]

The medial longitudinal arch plays a critical role in shock absorption and propulsion of the foot while walking to comprehend the function of the medial arch, the gait cycle must be understood. There are two phases in gait cycle, the stance phase and the swing phase. As the heel strike the ground, the foot is supinated, and ten it enters the stance phase. During mid stance the medial longitudinal arch is lengthened and flattened due to pronation of the forefoot. Elastic tendon and ligaments that become stretched during this phase store mechanical energy.[10,11]

The collapse of the arch in children has also correlated with obesity. Posterior tibial tendon dysfunction is the most common cause of acquired pes cavus. The classical presentation of this is a woman above the age of 40 with diabetes and obesity. Other structures of the medial longitudinal arch that can contribute to pes planus are the laxity of the plantar fascia, spring ligament, or other plantar ligaments.[12] Any type of trauma or injury to the midfoot or hindfoot can also lead to pes planus. Although it is usually asymptomatic, pes planus includes pain in the back, hip, knee, lower leg, heel, and midfoot. Patients also may present with a history of frequent ankle sprains due to overpronation while ambulating.

Material and Methods

This cross-sectional, observational approach, the current study included 350 young Indian individuals between the ages of 17 and 40. The participants were chosen at random from north Gujarat area; there were 240 men and 110 women. Each subject provided informed written permission prior to their enrollment in the study. During the examination, none of the patients displayed any neuro-muscular disorders, injuries, deformities, or discomfort in their lower limbs. Material requires are Custom-built foot length device, ruler scales, pencils, markers, retractor and markers were used in the investigation (Fig. 1)

Fig. 1

Before taking different foot measures, the observer palpated and noted each participant's navicular tuberosity and first metatarsal head. Usually, palpating the medial tubercle of the calcaneum allowed one to determine the posterior end of the Medial Longitudinal Arch (MLA). However, the current study chose to measure the length and angles of the MLA using the posterior most end of the foot as a reference point because it was difficult to palpate this particular site.

Measurements during the sitting position Fig. 2

Then the participant was asked to stand erect with equal weight on both the feet. The truncated foot length and Arch height in this position (weight bearing) were measured in similar fashion by an observer for both the feet. The difference in truncated foot length of individual during weight bearing and non-weight bearing position constituted Arch Spread [(41)] (AS). The Navicular Drop (ND) was measured by Broady's method [(3)] in which ND is the difference in Arch height of individual during non-weight bearing & weight bearing position. Thus, using Arch Spread (AS) and Navicular Drop (ND), the flexibility of Medial longitudinal arch was assessed in each individual.

First, each participant was told to sit comfortably with their hips and knees bent to a 90-degree angle and their foot supported gently on ground. Fig. 2


Fig. 2 **Fig. 3**

Now we will palpate then mark the certain anatomical landmarks of the foot. It include navicular tuberosity , head of first metatarsal and medial end of the calcaneum. Fig. 3

Now we measure the arch height with the help of rular scale in the sitting position of the participant. The metal rular scale taken and start measuring the arch height, first touch the metal scale on ground the touch the point where marked as navicular tuberosity. Fig. 4

Fig. 4

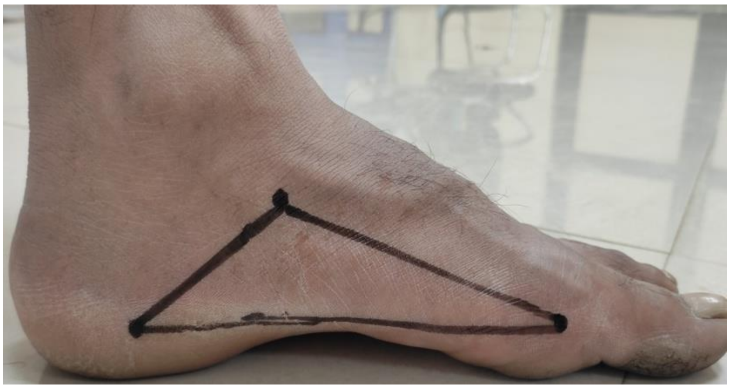


Fig. 5

Now we will connect the three points which we marked on the foot with the help of marker. Then we connect the all three marks with the help of rular scale and maker then make a triangle on medial surface of the foot. Fig. 5

Then we give the name of marked structure i.e. Point A, point B and Point C. point A is the navicular tuberosity , Point B is the head of 1st metatarsal and Point C is the medial end of the calcaneum.Fig 6

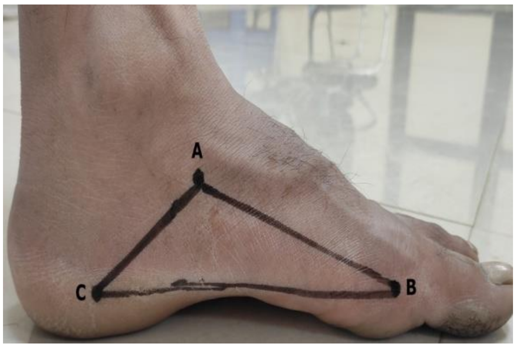


Fig. 6

Fig. 7.1

Then we measure the anterior arch angle which is formed by point ABC , posterior arch angle ACB and superior arch angle CAB with the help of protractor.Fig. 7.1 and 7.2

Fig. 7.2

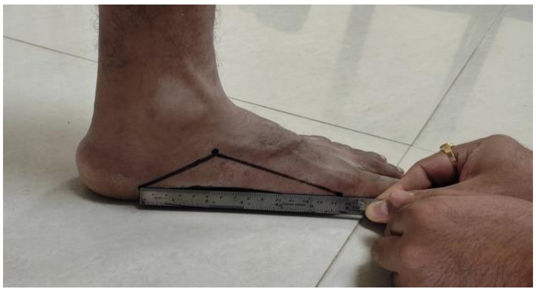


Fig. 8

We measure the last line which is known as arch length. Arch length is the line which connects point C and B. this line is measured by metal rular scale. Fig. 8
Navicular drop test
For checking navicular drop test, the subject was first positioned in standing i.e. weight bearing position. Using a small rigid ruler, the height of the navicular bone was measured from the floor to the most prominent part of navicular tuberosity when in the neutral talar position. Again the height of the navicular bone was measured in relaxed sitting position i.e. non weight bearing .The difference in measurement is the navicular drop and drop>10mm will be regarded as pesplanus**.**

Statistical Analysis

The normality of the data was tested using Shapiro-Wilk test. Mean, standered deviation, minimum and the maximum value is calculated. The Navicular drop test (NDT) compared with foot parameretrs. The criteria to determine flat foot was NDT of ≥ 10 mm. Using this criteria, the prevalence was calculated of north Gujarat ppulation. A p-value of less than 0.05 was considered statistically.

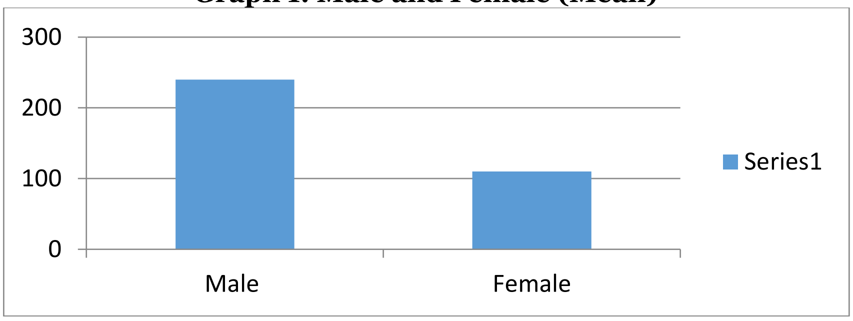
Results

350 young adults of age 17 to 30 participated in present study. Distribution of male and female among study population is shown in Table 1.

Table 1: Male and Female

Male	Female	Toatal
240	110	350

Graph 1: Male and Female (Mean)



The parameters used for assessment of anthropometric measurements of foot in sitting and position i.e. Arch Length (AL), Arch height (AH), Anterior Arch Angle (AAA), Posterior Arch Angle (PAA) and Superior Arch Angle (SAA), among Male and Female population is shown in Table 2&3.

Table 2: Anthropometric Measurements (Sitting Position)

		Male (N=240)					Female (N=110)				
		Mean	Median	Minimum	Maximum	Standard Deviation	Mean	Median	Minimum	Maximum	Standard Deviation
RIGHT	AH	5.380	5.300	5.380	7.000	0.682	5.530	5.500	4.300	7.500	0.747
	AAA	20.950	21.000	20.950	30.000	4.419	23.750	22.500	20.000	35.000	4.482
	PAA	34.600	30.000	34.600	70.000	14.716	42.450	39.000	27.000	70.000	11.569
	SAA	124.550	129.000	124.550	150.000	16.975	113.450	115.500	80.000	128.000	12.947
	AL	13.935	14.000	13.935	18.000	2.244	11.835	12.000	5.500	15.000	2.304
LEFT	AH	5.355	5.250	4.100	7.500	0.729	5.605	5.500	4.500	7.500	0.756
	AAA	21.250	20.500	10.000	30.000	4.778	23.700	23.000	17.000	30.000	3.643
	PAA	36.800	30.000	20.000	80.000	16.552	42.800	39.500	25.000	70.000	12.726
	SAA	122.950	127.000	82.000	145.000	18.042	113.850	114.000	80.000	135.000	14.698
	AL	14.025	14.500	10.500	17.500	1.909	12.115	11.900	9.000	15.000	2.026

		Male (N=240)					Female (N=110)				
		Mean	**Median**	**Minimum**	**Maximum**	**Standard Deviation**	**Mean**	**Median**	**Minimum**	**Maximum**	**Standard Deviation**
RIGHT	**AH**	5.380	5.300	4.100	7.500	0.729	5.605	5.500	4.500	7.500	0.756
	AAA	20.950	20.500	10.000	30.000	4.419	23.750	22.500	20.000	35.000	4.482
	PAA	34.600	30.000	20.000	70.000	14.716	42.450	39.000	27.000	70.000	11.569
	SAA	124.550	127.000	90.000	150.000	16.975	113.450	115.500	80.000	128.000	12.947
	AL	13.935	14.500	10.500	18.000	2.244	11.835	12.000	5.500	15.000	2.304
LEFT	**AH**	5.355	5.250	4.000	7.000	0.682	5.530	5.500	4.300	7.500	0.747
	AAA	21.250	21.000	10.000	30.000	4.778	23.700	23.000	17.000	30.000	3.643
	PAA	36.800	30.000	20.000	80.000	16.552	42.800	39.500	25.000	70.000	12.726
	SAA	122.950	129.000	82.000	145.000	18.042	113.850	114.000	80.000	135.000	14.698
	AL	14.025	14.000	10.500	17.500	1.909	12.115	11.900	9.000	15.000	2.026

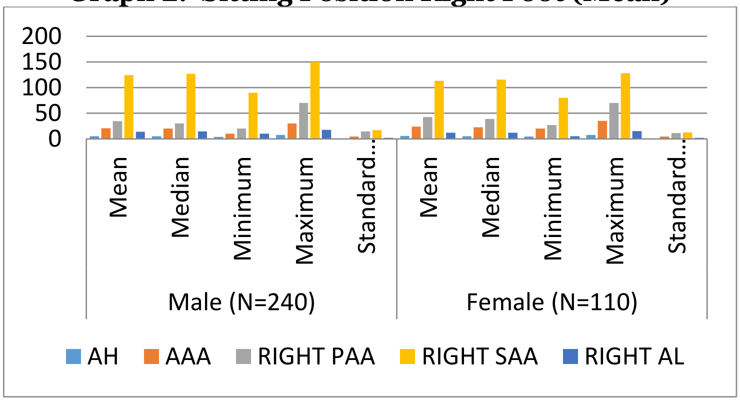
AL=Arch Length, AH=Arch height, AAA=Anterior Arch Angle, PAA=Posterior Arch Angle and SAA=Superior Arch Angle

Table 3: Anthropometric Measurements (Standing Position)

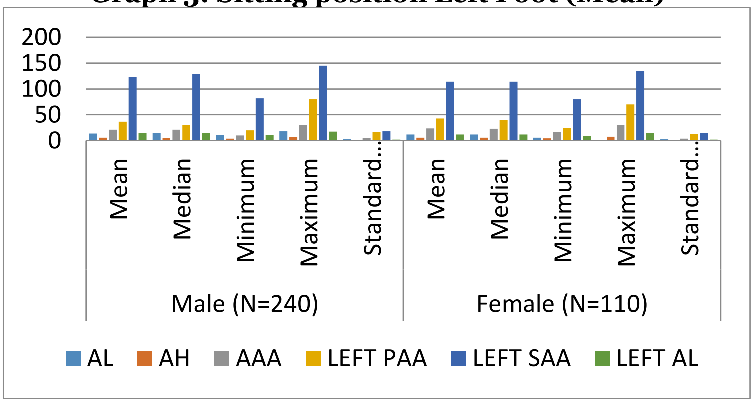
AL=Arch Length, AH=Arch height, AAA=Anterior Arch Angle, PAA=Posterior Arch Angle and SAA=Superior Arch Angle

These tables also show gender wise distribution of all above mentioned parameters. The Median and Mean for all the parameters are expressed as the data was found to be not normally distributed.

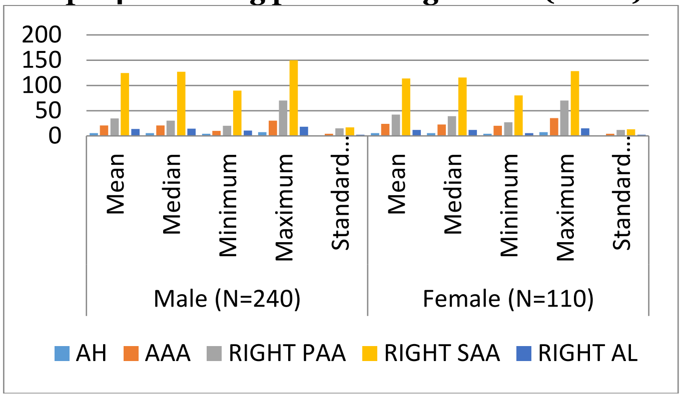
Graph 2: Sitting Position Right Foot (Mean)



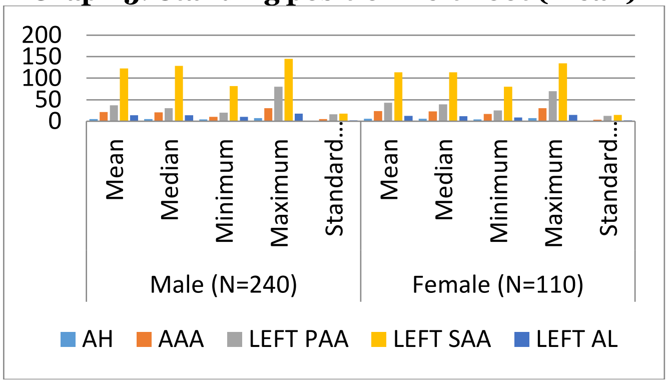
Graph 3: Sitting position Left Foot (Mean)



raph 4: Standing position Right Foot (Mean)



Graph 5: Standing position Left Foot (Mean)

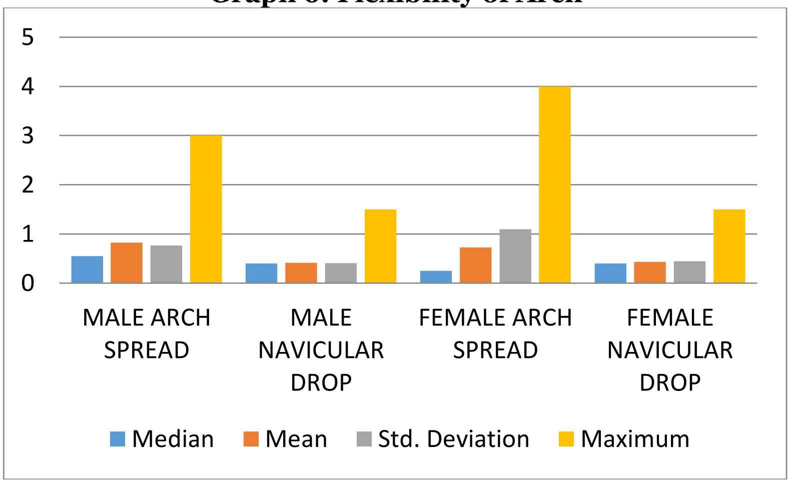


The current study used two metrics, namely Arch Spread (AS) and Navicular Drop (ND), to evaluate the flexibility of MLA among the sample group.

Table 4:Specifics of AS and ND in the study population

	MALE ARCH SPREAD	MALE NAVICULAR DROP	FEMALE ARCH SPREAD	FEMALE NAVICULAR DROP
Median	0.550	0.400	0.250	0.400
Mean	0.820	0.410	0.725	0.430
Std. Deviation	0.763	0.404	1.098	0.443
Minimum	0.000	0.000	0.000	0.000
Maximum	3.000	1.500	4.000	1.500

Graph 6: Flexibility of Arch



The present study attempted to find out correlation between demographic variables viz. Arch Height, Arch length and various foot parameters for male and females separately and for entire study population, using spearman's correlation (Table 5A, B, C).

Table 5A: Details of correlation among different foot parameters and demographic variables in male; correlation expressed in spearman s rho and p- value-

Variable		Right Side Arch height (Male)	Right Side Arch length (Male)	Navicular Drop (Male)	Left Side Arch height (Male)	Arch spread (Male)
Right Side Arch height	Pearson's r	—				
	p-value	—				
	Spearman's rho	—				
	p-value	—				
Right Side Arch length	Pearson's r	-0.150	—			
	p-value	0.528	—			
	Spearman's rho	0.005	—			
	p-value	0.985	—			
Navicular Drop	Pearson's r	0.056	-0.077	—		
	p-value	0.814	0.747	—		
	Spearman's rho	0.031	0.027	—		
	p-value	0.897	0.911	—		
Left Side Arch height	Pearson's r	0.621	-0.188	-0.170	—	
	p-value	0.003	0.428	0.473	—	
	Spearman's rho	0.506	-0.149	-0.082	—	
	p-value	0.023	0.532	0.731	—	
Arch spread	Pearson's r	-0.063	-0.191	0.297	-0.020	—
	p-value	0.792	0.420	0.204	0.933	—
	Spearman's rho	-0.107	-0.065	0.426	-0.109	—
	p-value	0.653	0.785	0.061	0.648	—

Table 5B: Detail of correlation among different foot parameters and demographic variables in female; correlation expressed in spearman s rho and p- value-

		Right Side Arch height (Female)	Right Side Arch length (Female)	Navicular Drop (Female)	Left Side Arch height (Female)	Arch spread (Female)
Right Side Arch height	Pearson's r	—				
	p-value	—				
	Spearman's rho	—				
	p-value	—				
Right Side Arch length	Pearson's r	0.140	—			
	p-value	0.557	—			
	Spearman's rho	0.324	—			
	p-value	0.163	—			
Navicular Drop	Pearson's r	-0.245	0.038	—		
	p-value	0.298	0.873	—		
	Spearman's rho	-0.282	0.016	—		
	p-value	0.228	0.946	—		
Left Side Arch height	Pearson's r	0.647	0.166	-0.238	—	
	p-value	0.002	0.484	0.312	—	
	Spearman's rho	0.497	0.340	-0.221	—	
	p-value	0.026	0.142	0.349	—	
Arch spread	Pearson's r	0.125	-0.527	-0.082	-0.022	—
	p-value	0.600	0.017	0.732	0.928	—
	Spearman's rho	-0.109	-0.251	0.116	-0.092	—
	p-value	0.647	0.285	0.626	0.699	—

Very strong positive correlation was found between Foot Length and Height of individual for both feet which was statistically significant. Foot Length also showed strong positive correlation with Navicular drop of individual which were statistically significant. The correlation of Arch Height (AH) with demographic variables i.e. height and weight of individual were moderately positive, weak positive respectively. The Foot Length also showed weak positive correlation with Arch height (AH). Arch Spread (AS) showed weak positive correlation with Height and Weight of individuals.

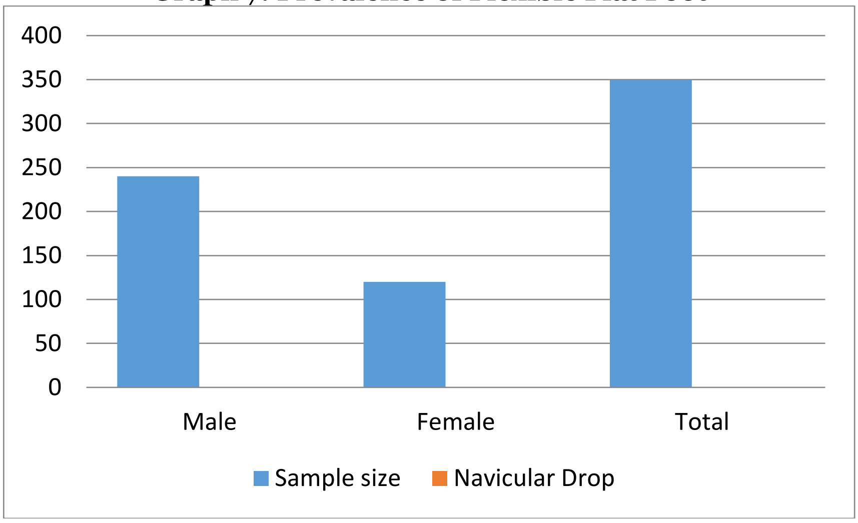
The Present study also compared differences between male & female groups of study population for various Right and Left foot parameters.

The results showed that the differences between these two groups for Foot Length, Arch Height, and ArchSpread & Navicular Drop (ND) were statistically not significant except for the Navicular Drop (ND) for left foot.
The criteria to determine flexible flat foot used by the present study was Navicular drop ≥10mm. In the study population, 12.5% individuals were found with navicular drop of ≥ 10mm in both feet (Male = 10% & Female = 14.4%). The prevalence of flexible flat foot was calculated using the above mentioned criteria (Table 7).

Table 7: Prevalence of Flexible Flat foot in study sample

	Sample size	Navicular Drop
Male	240	24 (10%)
Female	120	17 (14.4%)
Total	350	44 (12.5%)

Graph 7: Prevalence of Flexible Flat Foot



Discussion

Normal values for navicular drop during walking: a new model correcting for foot length and gender[13]

Navicular drop was measured with a novel technique (Video Sequence Analysis, VSA) using 2D video. Flat reflective markers were placed on the medial side of the calcaneus, the navicular tuberosity, and the head of the first metatarsal bone. The navicular drop was calculated as the perpendicular distance between the marker on the navicular tuberosity and the line between the markers on calcaneus and first metatarsal head. The distance between the floor and the line in standing position between the markers on calcaneus and first metatarsal were added afterwards.[13]
280 randomly selected participants without any foot problems were analysed during treadmill walking (144 men, 136 women). Foot length had a significant influence on the navicular drop in both men ($p < 0.001$) and women ($p = 0.015$), whereas no significant effect was found of age ($p = 0.27$) or BMI ($p = 0.88$). Per 10 mm increase in foot length, the navicular drop increased by 0.40 mm for males and 0.31 mm for females. Linear models were created to calculate the navicular drop relative to foot length.[13]
In current study the percentage of navicular drop is 12.5 in whole population and in male 10 and in female 14.4%.

	Sample size	Navicular Drop
Male	240	24 (10%)
Female	120	17 (14.4%)
Total	350	44 (12.5%)

Measure and categorize the different types of the arch of foot of adult Bangladeshi males using digital photography and calliper[14]

The height of the medial longitudinal arch of the foot is commonly thought to be a predisposing factor to injuries. High-arched runners exhibited more bony, ankle and lateral injuries but low-arched runners revealed a higher risk of soft tissue, knee and medial injuries. Again, both high and low-arched people had greater rearfoot eversion excursions than those with normal arch structure. This indicates the importance of measuring and determining the types of the foot arch in Bangldesh as there is no such data.[14]

In our study the mean value of arch height in sitting position is and arch height in standing position is in males. The mean value of arch height in sitting position is and arch height in standing position is in females.

Relations between anthropometric factors and flat feet[15]

The study population consisted of 243 school children in Qom, with an average age of 11.47±0.82 years, weight 39.4±10.86 kg, and height 145.94±7.91 cm. To assess the foot condition, the foot arch index Staheli, Arch Index (AI or Arch Index), and anthropometric factors were used to assess the amount of fat (by Jackson Pollock) and BMI. To calculate the relationship between variables, the chi-square test (Ci-square), with confidence interval of 95% and to check the repeatability of the data, the correlation coefficient (Interclass correlation coefficient) was run.[15]

In current study the data was collected from the general population of north Gujarat including the students, farmers etc. the arch height, arch length and other parameters of the medial longitudinal arch foot are strongly related to the flat feet.

Navicular position test a reliable measure of the navicular bone position during rest and loading[16]

Lower limb injuries are a large problem in athletes. However, there is a paucity of knowledge on the relationship between alignment of the medial longitudinal arch (MLA) of the foot and development of such injuries. A reliable and valid test to quantify foot type is needed to be able to investigate the relationship between arch type and injury likelihood. Feiss Line is a valid clinical measure of the MLA. However, no study has investigated the reliability of the test.[16]

In current study we mark the navicular tubersosity for the measurements of the navicular drop. Navicular tuberosity is the very important landmark for the determination of the flat foot and help in diagnosis of pes palnus.

Morphology of Medial Longitudinal Arch among young Indian adult[17]Indian database on morphology of Medial Longitudinal Arch (MLA) especially in young adults is extremely limited. So the present study was undertaken to estimate quantitative morphology of MLA and to evaluate influence of demographic variables on it, in Indian young adult population from Gujarat region. Materials and Method: Various dimensions of MLA were measured with custom made Bronnack device in 1500 (670- male, 830- female) healthy volunteers of age 17-21yrs in non weight bearing & weight bearing positions which were plotted on paper for additional measurements.[17]

In present study we measures all the important parameters of the medial longitudinal arch of foot i.e. arch height , arch length, navicular tuberosity position , anterior arch angle , posterior arch angle and superior arch angle.

Prevalence of Flexible Flat Foot in Adults[18]

Brody's Navicular Drop Test was performed in five hundred healthy subjects (250 males and 250 females) aged 18-21-year-old. Navicular Drop (ND) of ≥ 10 mm was regarded as flexible flat foot. Statistical analysis was done using SPSS version 23.0. Results: The prevalence of flexible flat foot was 13.6% (for males-12.8%; for females-14.4%). The median with Inter Quartile Range (IQR) for ND among males was 6 mm (4-8) and 6 mm (4-9) for right and left foot respectively.

Prevalence of flat foot among medical students[19]

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.[19]

Prevalence of flat foot among 18 -25 years old physiotherapy students[20]

Pes-planus ('flat foot') is one of the most common conditions observed in adult health practice. The objective of our study was to find out prevalence of flat foot in a population of 18 to 25 year old physiotherapy students and to find out correlation of BMI with arch index Methodology: A cross sectional study was conducted with sample of 80 physiotherapy students fitting in inclusion criteria. Different outcome of the study that is navicular drop test, arch index, foot posture index were assessed for each subject. Result : Prevalence of flat foot in a population of 18 to 25 years old physiotherapy students was 11.25% for all subject affected with bilateral flat foot. According to the age, 18 years were having 2.5% of flat foot bilaterally, 19 years were having 3.75% flat foot bilaterally, 22 years were having 3.75 % flat foot bilaterally, 24 years were having 1.24% flat foot bilaterally. The mean Navicular drop test value was 11.11 for all subject affected with bilateral flat foot and 6.66 for normal subjects & pronation score (FPI) for flat foot subjects mean was 7.44 (+6 to +11) bilaterally.[20]

In present study the prevalance of flat foot in northern gujarat position is 12.5 % and in male it is 10% and in female it is 14.4 % according to the navicular drop test.

Conflict of interest: None declared.

Sources of funding: Nil.

Conclusion

Based on the result and the methodology employed , we have conducted that, in present study on 350 random population between the age group of 17to 35 years, the prevalence of unilateral flat foot 12.5 % (10% were males and 12.5% were females). The navicular drop test is the simplest test that can be used to clinically evaluate the position of the navicular bone in the weight bearing position.

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