



## RESEARCH ARTICLE

### STUDY OF CORRELATION BETWEEN PLANTER ARCH INDEX AND BMI IN YOUNG ADULTS

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#### ABSTRACT

**Background:** The arches of foot provide functions of force absorption, base of support and acts as a rigid lever during gait propulsion. The assessment of plantar arch development, by the relationship between arch region width and heel region width obtained on a footprint, is proposed by Engel and Staheli's. **Objectives:** The purpose of study the correlation between Planter Arch Index and BMI in young adults. **Methods:** All 30 participants were given informed consent and were assessed according to age group i.e, 20-25 years. The BMI was calculated and planter arch index was taken with the help of Staheli's PLANTER ARCH INDEX. The footprint was taken and A value (Width of central region of footprint) and B value (Width of heel region of footprint) were calculated and both value were correlated and result was found. The study design was Correlation. The statistical analysis was Pearson's Correlation. **Results:** All subject were assess with the steheli's planter arch index and their BMI was calculated. According to Pearsons's Correlation, the r value of right side (0.36) and r value of left side (0.43) suggest that there is a positive correlation. **Conclusion:** The planter arch index is easy to obtain from footprints and that there are no differences in Right and Left Side. There is a significant correlation between planter arch index and BMI. This may lead to long term flat feet due to changes in arches especially medial longitudinal arch. There is no difference in right side and left side to BMI. Both are correlating with BMI.

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## INTRODUCTION

The foot and ankle form a complex system which consists of 28 bones, 33 joints, 112 ligaments, controlled by 13 extrinsic and 21 intrinsic muscles. It functions as a rigid structure for weight bearing and it can also function as a flexible structure to conform to uneven terrain and supporting body weight, providing balance, shock absorption, transferring ground reaction forces, compensating for proximal malalignment, and substituting hand function in individuals with upper extremity amputation/paralysis (Houglum *et al.*, 2012). The arches of foot provide functions of force absorption, base of support and acts as a rigid lever during gait propulsion. The medial longitudinal arch, lateral longitudinal arch and transverse arch are the 3 arches that compromises arches of foot. The arch is supported by the plantar aponeurosis, by the small muscles in the sole of the foot, by the tendons of

the Tibialis anterior and posterior and Peroneus longus, and by the ligaments of all the articulations involved (Henry Gray, 1821-1865). Peroneus longus tendon plays an important role in maintaining the lateral border of the arch (Henry Gray, 1821-1865). The medial and lateral pillar of the arch is formed by medial and lateral longitudinal arch respectively. The arch is maintained by posterior tibialis tendon and peroneus longus tendon which cross the plantar surface from medial to lateral and lateral to medial respectively (Henry Gray, 1821-1865).

There are two deformities 'flat feet' and 'pes cavus'. Flat feet is an alteration of the longitudinal and transverse arch of the foot, which determines an increased footprint on the ground, it involves multiple joints and can cause forefoot pathologies. The pes planus commonly known as flat feet or arches is a medical condition in which the arc showing the length of the leg is flattened outwards or downwards. Flat feet may affect one of the legs or both, and not only increases the amount of leg that acts on the leg structure, but also interferes with normal foot function. As a result, those with a flat foot experience upsetting during periods of prolonged time (Cavangah, 1987).

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The symptoms of the flat foot include softness of the palm of the foot, collapse of the ligaments, rapid fatigue of the leg, pain with pressure and instability of the middle structure of the feet (Queen *et al.*, 2007). Flexible flatfoot function normally. Most children are born with very little arch in the feet. As they grow and walk, the soft tissues along the bottom of the feet tighten, which gradually shapes the arches of the feet (Messier, 1988). Arch Index -As a sensitive podographic indicator was later on confirmed in different studies (Staheli *et al.*, 1987). It has been established the Arch Index, derived from footprint to show a significant negative correlation with the navicular height (Maheshwari, 1997). Arch index also varies with age, falling into the normal adult range by age 5 year. Whether among obese or non-obese people, school-aged children or adults, or men or women from different countries, arch index values fall into the different ranges of arch index values suggested and used as a potential method to classify high-arched, normal, and low-arched foot types. An arch index of less than 0.21 has been said to be indicative of a cavus foot, while if greater than 0.26 is indicative of planus foot whereas Arch Index between 0.21~0.26 corroborates normal arch height.

Reliability of these measurements in classifying foot type has not been investigated. Arch index values, based on the contact area of the middle section of the plantar footprint, have been used to determine foot type. Arch index values calculated by footprint analysis have been obtained from force plate. The high arched cavus foot has been associated with low back facet syndrome and knee pain, while the low arched planus foot has been linked with pathological including Moron's neuroma, plantar fasciitis, hallux abductor valgus, chondromalacia patella and shin splints (Daneshmandi *et al.*, 2003). The assessment of plantar arch development, by the relationship between arch region width and heel region width obtained on a footprint, is proposed by Engel and Staheli's. This relationship is greatly reduced up to 4 years old, and the standard deviation through this age group is very high, showing a large variation at the initial foot arch development. The longitudinal arch during childhood shows a wide variation, and, from 4 years old on, this relationship remains at about 0.75 in average If PAI is greater than 1.15, then it is considered as flat foot.  $PAI = A/B$   
Plantar arch index = A/B

A - Width of central region of footprint.

B - Width of heel region of footprint.

In normal feet with presence of an arch, the stress will be distributed in an even manner so that the person will not experience any kind of pain. Under an abnormal condition that occurs due to lack of stretching of muscles, bones and tendons, there will be absence of arch among these people. In this condition, all the weight will be concentrated in smaller area on the feet and generates a lot more pain than normal (Singrolay, 2016). Body Mass Index (BMI) is an indicator of functional and easily estimated relative weight and is largely linked to most direct obesity measures. The BMI depends to a large extent on the physical composition. BMI is a tool for evaluating healthy body weight. BMI is calculated by measuring the ratio of individual weight to height squared and is used to determine obesity and overweight. Several reports have shown that overweight and obesity may affect foot structure in children and adults (Dowling *et al.*, 2001; Daneshmandi *et al.*, 2003)  
 $BMI = \text{Weight}/(\text{Height})^2$

Main contributing factors for the increase in body mass index is sedentary lifestyle, foods in high fat and calories. Stress is also an important factor for obesity. Growing older, this can lead to less muscle mass and a lower metabolism making it easier to gain weight. Body mass index is used differently for children. It is calculated the same way as for adults, but then compared to typical values for other children of the same age. The Body mass index is generally used as a mean of correlation between groups related by genera mass and can serve as a vague means of estimating adiposity (Gardner, 1989). Thus in the study we are going to conclude correlation between Plantar Arch Index and BMI.

## MATERIALS AND METHODOS

### Materials

- Pen, Pencil, Book, Scale
- Blank Paper
- Ink
- Weighing Machine
- Stadiometer.

The Study Group of 30 Normal young individual of age group 20-25 years.

### Inclusion Criteria

- Subject having age criteria of 20-25 years.
- Willing to participate.

### Exclusion Criteria

- History of Trauma fracture of lower limb and pelvic.
- Presence of open wound on foot
- Recent injury.

## METHODOLOGY

**Procedure:** Firstly, inform consent was taken from the subjects, who were willing to participate. 40 subjects were studied among them 10 did not agree for foot impression, so study was done with 30 subjects. The following information was recorded from each subject: Name, height and weight. The weighing machine was used to measure the weight. Height was measured using a stadiometer. Their BMI was noted and categorization was made as underweight, normal, overweight. In this study Static weight bearing foot prints for the right and left foot of each subject was recorded by marking the sole of the foot and making an impression of it on blank paper. The calculation of PI (planter index) was done using Staheli's planter arch index method and using the values correlation of PI & BMI were calculated. In Staheli's Planter Arch Index, a sheet of paper is placed on the platform and the surface impregnated with stamp ink face paper's upper surface. The young adult remains seated in front of the platform. With the aid of an investigator, the young adult places the foot to be studied on the rubber layer, with contralateral foot out of the platform.

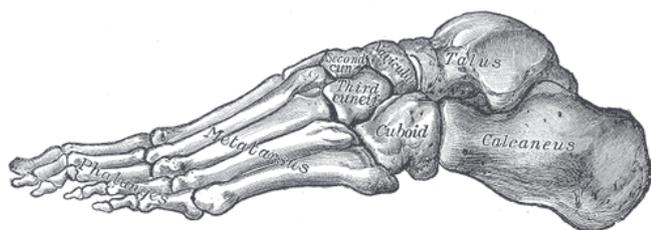


Figure 1. Normal foot lateral view

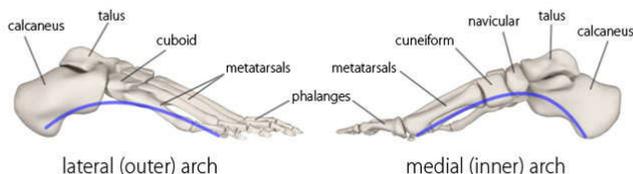


Figure 2. Lateral and Medial arch of foot



Figure 3. Deformities of the foot

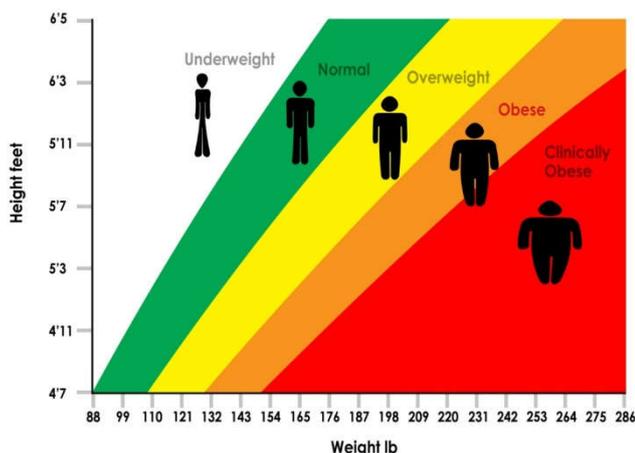


Figure 4. Presentation of BMI classification

We requested the young adult to stand up and perform a small flexion of the ipsilateral knee (about 30°), with the aid of the investigator and, then, to go back to the initial position, removing the foot from the platform. The investigator control foot position on the platform so as to prevent foot slip, a fact that would invalidate the test, which should show a clear footprint. Calculation of the Plantar Arch Index was done. It establishes a relationship between central and posterior regions of the footprint, and it is calculated as follows: a line is drawn tangent to the medial forefoot edge and at heel region. The mean point of this line is calculated from this point, a perpendicular line is drawn crossing the footprint. The same procedure is repeated for heel tangency point. Thereby, they are marked as support width of the central region to the foot (A) and of the heel region (B) in millimeters.



Figure 5: Measurement of the width of the central region (A) and heel region (B) of the foot, in millimetres, on footprint. The plantar arch index is obtained by dividing A value by B value



Figure 6. Measurement of the width of the central region (A) and heel region (B) of the foot, in millimetres, on footprint. The plantar arch index is obtained by dividing A value by B value.

The plantar arch index (PI) is obtained by dividing the A value by B value (PI = A/B).

**RESULTS AND STATISTICAL ANALYSIS**

For the analysis, data were obtained using Staheli’s arch index and BMI. The analysis was done using SPSS software and Pearson’s correlation co-efficient (r) was calculated, the values obtained were r= (0.363) right feet and (0.432) left feet and P value for right feet (0.049) and left feet (0.017) was found out. Their values showed positive correlation between both BMI and Staheli’s arch index.

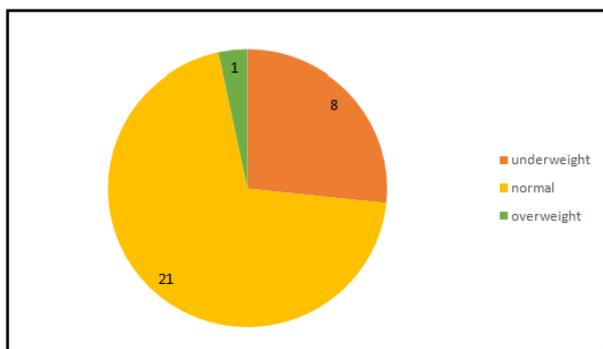
**Table 1. Classification of BMI**

Underweight	15–19.9
Normal weight	20–24.9
Overweight	25–29.9
Preobesity	
Class I obesity	30–34.9
Class II obesity	35–39.9
Class III obesity	≥40

The Table 2. and Graph 1 shows the values of the no. of student in age group of 20-25 years having different BMI classification.

**Table 2. No. of Subjects in Underweight, Normal and Overweight**

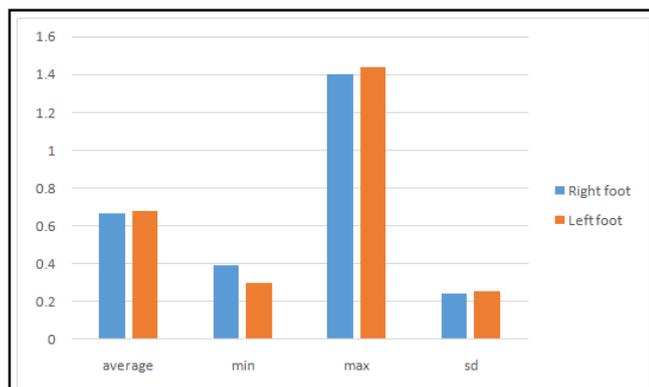
	No of student.
Underweight	8
Normal	21
Overweight	1



**Graph 1. Graphical presentation of no. of student in underweight, normal and overweight**

**Table 3. Values for Average, minimum, maximum, and standard deviation of the measurement of the central region of arch (A) and heel (B) on footprint, and of the planter arch index (PI) for the right and left foot**

	Right	Left
Average	0.66633333	0.67833333
Minimum	0.39	0.3
Maximum	1.4	1.44
Standard Deviation	0.24176412	0.25548755



**Graph 2. Graphical representation of Average, Minimum, Maximum and Standard Deviation of Right Foot and Left Foot**

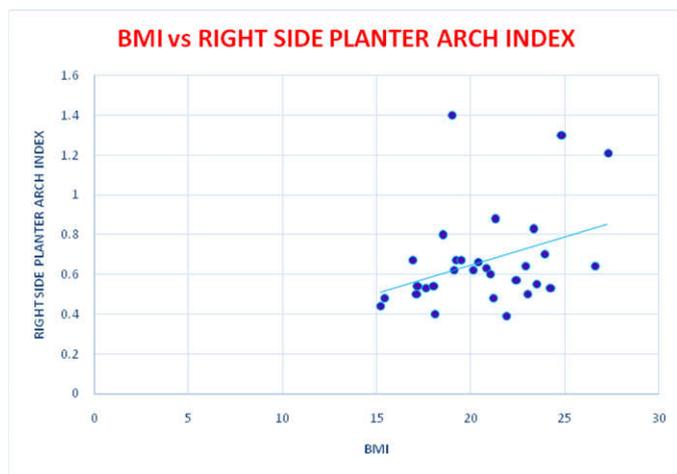
Table 4 shows correlation value i.e, pearsons correlation of right side and left side with BMI and P values for the same which signifies that there is correlation between right side and left side and BMI with values  $r$  (Right)=0.363 ,  $r$  (Left)=0.432 respectively.

**Table 4. Correlation value(r), P value and significant level of right feet and left feet.**

	Correlation value(r)	P value	Significant level
Rt. Feet	0.363*	0.049	Significant
Lt. feet	0.432*	0.017	Significant

\*Correlation is significant at the 0.05 level (2-tailed)  
Observation shows that correlation between BMI and planter arch index PI is significant for both the sides with correlation value 0.36 for right side and 0.43 for left side and  $p < 0.05$  for both the side.

Graph 3 and Graph 4 represents scatter diagram of correlation of Right side with BMI and correlation of Left side with BMI respectively. There is positive correlation between Planter Arch Index and BMI.



**Graph 3. Garpical representation of correlation between BMI and RIGHT SIDE PLANTER ARCH INDEX**



**Graph 4. Graphical representation of correlation between BMI and LEFT SIDE PLANTER ARCH INDEX**

**DISCUSSION**

In present study we took inform consent. 40 subject were taken and 10 did not agree for foot impression so study was done with 30 subject, 15 male and 15 female young adult in the age group of 20-25 years. We measured their height by using standiometer and the weight was measured using weighing

machine. BMI were calculated by weight (kg) /Height (meter)<sup>2</sup>. In this study we calculated PI (planter index) by using Staheli's planter arch index method and correlation of PI and BMI was done. The foot has two functions: to be a strong and stable support for the body, and the lever to ambulation. This double function makes feet to present a unique behaviour during ambulation, when it is submitted to a successive load and unload cycle. The deformation experienced by the medial longitudinal arch during support makes feet to be the region suffering the highest variations in a human body. So, as the weight of the human body increases the biomechanical changes takes place and it can lead to flat feet. The conclusion can be related to the fact that ambulation and arch of the feet which changed can lead to flat feet.

Similarly, the orthopaedic examination served to recognize disorders that are known to change feet consistency. The identification of congenital problems, particularly involving the feet postural abnormalities of the spine, pelvis, hips and knees Achilles Tendon shortening and restraint to subtalar joint movements are essential for ruling out the possibility of secondary flat feet. In previous study, Pranali .V. Gaikwad and Dr. Shyam .D. Ganvir conducted the study of PREVALENCE OF FLAT FEET IN SCHOOL GOING BOYS AND GIRLS IN AHMEDNAGAR DISTRICT. This study suggests that there is a significant association between flat foot and age. Prevalence of flat foot decreases with advancing age. From the result it is concluded that Flat foot is highly prevalent in the ages between 9-15 years. Similarly from the present study we concluded that it is also common among the age group of 20-25 years. In one study done by D.Krupa Daniel *et al* A STUDY ON PREVALENCE OF FLAT FEET AMONG SCHOOL CHILDREN IN KANCHIPURAM POPULATION. The study shows that Flat foot is highly prevalent in the ages between 5-9. In our study there were 30 subjects out of them 8 subjects were under weight, 21 were normal and 1 was overweight. Thus, through conclusion of the study it suggested that, when mass increases then there is increased static and dynamic plantar pressures, causing significant change to the structure of the foot. However, long-term mass increases associated with obesity appeared to flatten the medial longitudinal arch of the subjects as confirmed by an increased area of foot contact with the ground. Although obesity and overweight is a temporary, but it can be the cause of flatfoot. Therefore subjects should pay attention to increasing weight that may cause flatfoot and also other problems in the future.

## Conclusion

In our study, we concluded that there is a significant correlation between plantar arch index and BMI. This may lead to long term flat feet due to changes in arches especially medial longitudinal arch. There is no difference in right side and left side to BMI. Both are correlating with BMI.

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