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Original Research Article

# EFFECT OF BODY WEIGHT ON ARCHES OF FOOT-A CORRELATIVE STUDY BETWEEN BMI AND ARCH INDEX

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## ABSTRACT

**Introduction:** The arches of the feet are important in protecting the internal structures of the body from impact forces while it mainly helps in transferring the internal forces to the ground and are also involved in lifting the body weight and mainly shock absorption With respect to the medial longitudinal arch some prominent deformities can be observed - high arch i.e., Cavus foot and low arch i.e., flat foot also known as Pes planus. The deformities are responsible for inefficient transmission of forces leading to foot diseases.

**Objectives:** The present study is an attempt to know the effect of body mass index on plantar arches. This is useful in creating awareness about the plantar arch deformities and the cause for the deformity. The parameters used in measuring the plantar arch height are Staheli's plantar arch index and arch angle.

**Methodology:** Over the course of two months study was conducted on 106 subjects within the age group of 18-22years. Body Mass Index of the subjects are calculated using height and weight of the subject. Plantar arch index and arch angle were classified underOne wayANOVA test and chi square test. Measurement of the plantar arch index is done by using Staheli's arch index and arch angle will be done by using foot print method.

**Conclusion:** In this study it is shown that BMI is significantly associated with Arch index and Arch angle. Arch index is significantly higher in obese and overweight subjects than underweight and normal subjects. Arch angle is significantly higher in underweight and normal subjects than obese and overweight subjects. In the present study by comparing overweight and obese subjects with underweight and normal subjects, the obese and overweight subjects are more prone to have flatfoot.

**KEY WORDS:** Arches Of Foot, BMI, Arch Index, Arch Angle.

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## INTRODUCTION

The human feet are very complex in nature, having different components working together to provide balance, flexibility, mobility, and support to the body [1]. The plantar arches of the feet are the most distinctive feature of a human being. The arches of the feet are important in protecting the internal structures of the body from impact forces while it mainly helps in transferring the internal forces to the ground, are also involved in lifting the body weight, and mainly shock absorption [2].

The arches are classified into the longitudinal arches and the transverse arches. These arches maintain proportional distribution of the body weight. Concavity of the arches protects the plantar vessels and nerves from compression. When foot is on the ground the arches flatten somewhat, but when off the ground they restore the original contour. So it works like spring to

help in jolting and jumping from the height [3]. The arches present right from birth, although they are masked in infants by excessive amount of fat in their soles.

The foot has to act

a) As a pliable platform to support the body weight in the upright posture and

b) As a lever to propel the body forwards in walking, running or jumping [4]. Feet are the foundation of our bodies and they assist us in some of the most basic functions of living. Each foot contains 26 bones, which are controlled by multiple ligaments, muscles and tendons.

Through activities of living, the feet can change structurally over time, causing a reshaping of the feet. This can give rise to a number of medical condition and deformities.

**High Arch Foot or Pes Cavus:** In a normal foot, the gait cycle (walking) begins with the arch in a flattened position, allowing the foot to be loose enough to adapt to the terrain. When the leg is perpendicular to the ground, the arch begins to rise to allow the foot to lock and support the body weight as it is propelled forward. In individuals with a flat foot (Pes planus), the foot stays loose and unlocked [5]. In those individuals with high arched foot(Pes cavus), the arch does not flatten with weight bearing [6] and the foot stays locked, the foot is not flexible and thus pounds the ground as the person walks.

**Flat Foot or Pes Planus**: The opposite of high arched foot is a flat foot(pes planus),which, due to its structure, is "loose".Flat foot is among the most common structural deformities of the foot, in which the medial arch is collapsed or begins to collapse at some point [5]. This deformity can be congenital or acquired if ligaments can no longer support the foot structure.

The height of the arch is believed to be functionally significant for the mechanics of the foot. Although no correlation has been found between arch height and performance in jumping, running, lifting, weight bearing, balancing, strength and flexibility, arch height has been related to the occurrence of femoral, tibial and metarsal stress fractures [6].

High BMI some time may be a cause of flat foot.Therefore, the present study is an attempt to know whether increase in BMI of the subject will have any effect on arches of foot by comparing BMI with Arch angle and Arch index. There is a functional relationship between the structure of the arch of the foot and the biomechanics of the lower leg. The arch of the foot provides an elastic, springy connection between the forefoot and the hind foot. This association safeguards so that a majority of the forces incurred during weight bearing of the foot can be dissipated before the force reaches the long bones of the leg and thigh [7].

**Aims and Objectives:** The present study is aimed to know the effect of BMI on the plantar arches, and it's further effects over flat feet and high arched feet by comparing it(BMI) with foot parameters like Arch Index and Arch Angle. This is useful in creating awareness about the plantar arch deformities and cause for the deformity, by considering foot parameters like Arch Angle and Arch Index.

## MATERIALS AND METHODS

Materials required for BMI include weighing machine, height measuring tape. Materials required for Staheli's plantar arch index and arch angle are measuring scale, protractor, ink pad, ink bottle, graph papers, compass.

The subjects to be studied are 106 adults in the age group of 18-22 years of age.

**Exclusion Criteria:** Foot deformity, Existing neurological problem, Surgery within 6 months of data collection.

Body Mass Index of the subjects are calculated using height and weight of the subject.

BMI is defined as the individual's body weight in kg divided by the square of his or her height in meters. The formulae universally used in medicine (S I unit) produce a unit of measure of $kg/m^2$ [8].

Measurement of plantar arch index is done by Staheli's arch index and arch angle is done by using footprints. A plantogram of the weight bearing surface of the feet was taken on graph paper using ink pad with the subject standing with feet on the ground, with his full body weight.

The outlines of the entire footprint and the toeless footprint were traced and geometrically defined points on the ground were marked. Staheli's plantar arch index is calculated as

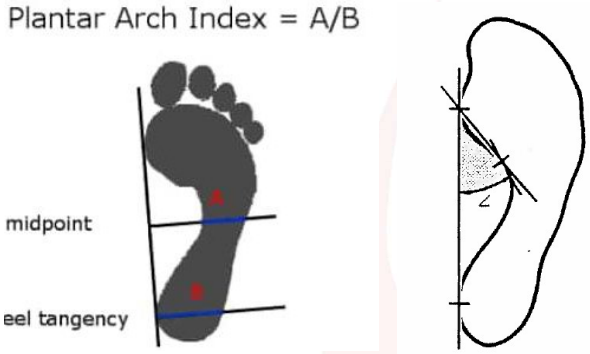
follows:

· Straight line is drawn and the medial most points heel and metatarsal region .

· A line perpendicular to this is drawn from its midpoint across the footprint. The width of this perpendicular is 'A'.

· The same is repeated in the heel region. The width of this perpendicular is 'B'.

· Then the ratio of A/B is calculated [9].




**Arch Angle:** To determine the arch angle, first line segment is taken in the medial border line of the footprint. A second line segment is drawn from the first point of the first line segment to the point where the slope of the arch meets the metatarsal outline of the arch.

## OBSERVATION AND RESULTS

The figure shows the Arch angle and Arch Index of the Right foot of the **Underweight** subject

**Table 1:** Shows the classification of 106 subjects into **A- Underweight B- Normal C- Overweight D-Obese** based on their Body Mass Index**(BMI)**.

| Sl.no | BMI Classification | Number of Subjects | Mean BMI(Kg/m$^2$) |
|---|---|---|---|
| 1 | Under weight | 9 | 17.77 |
| 2 | Normal | 59 | 21.84 |
| 3 | Over Weight | 29 | 26.88 |
| 4 | Obese | 9 | 32.13 |
| | Total | 106 | 24.65 |

**Table 2:** Arch index of right foot of the classified subjects.

| Arch Index Right foot | Number of subjects. | Mean value | Std. Deviation | F value | p value |
|---|---|---|---|---|---|
| Under weight | 9 | 0.59 | 0.19 | 7.31 | p<0.05 |
| Normal | 59 | 0.62 | 0.15 | | |
| Over Weight | 29 | 0.69 | 0.23 | | |
| Obese | 9 | 0.93 | 0.29 | | |
| Total | **106** | **0.66** | **0.21** | | |

**Table 3:** Arch Index of left foot of the classified subjects.

| Arch Index Left foot | Number of subjects. | Mean value | Std. Deviation | F value | p value |
|---|---|---|---|---|---|
| Under weight | 9 | 0.62 | 0.18 | 8.9 | p<0.05 |
| Normal | 59 | 0.61 | 0.15 | | |
| Over Weight | 29 | 0.73 | 0.25 | | |
| Obese | 9 | 0.97 | 0.31 | | |
| Total | 106 | 0.68 | 0.22 | | |

From the above table and graph of the Left foot, the Mean Arch Index of obese subjects are 0.97 and that ofoverweight subjects are 0.73, which is higher than underweight (0.62) and normal(0.61) subjects, calculated by applying one way **ANOVA test**."F" value is 8.90 which are more than the right foot." P" value is <0.05 showing significant change in arch index among the above groups.

**Table 4:** Arch angle of right foot of the classified subject.

| Arch Angle Right foot | Number of subjects. | Mean value | Std. Deviation | F value | p value |
|---|---|---|---|---|---|
| Under weight | 9 | 37.11 | 3.69 | 10.73 | p<0.05 |
| Normal | 59 | 38.27 | 6.86 | | |
| Over Weight | 29 | 32.31 | 10.57 | | |
| Obese | 9 | 21.89 | 14.68 | | |
| Total | 106 | 35.15 | 9.81 | | |

From the above table and graph, the Mean Arch Angle of Normal and Underweight subjects are 38.27 and 37.11 respectively. This is higher than overweight (32.31) and obese subjects (21.89) calculated by applying ONE WAY ANOVA TEST. "F" value is 10.73 and "p" value is <0.05 showing the significant change in the Arch Angle among the above groups.

**Table 5:** Arch angle of left foot of the classified subjects.

| Arch Angle Left foot | Number of subjects | Mean Value | Standard Deviation | F value | P value |
|---|---|---|---|---|---|
| Underweight | 9 | 38.89 | 3.89 | 9.9 | P<0.05 |
| Normal | 59 | 37.29 | 6.48 | | |
| Overweight | 29 | 32.55 | 11.58 | | |
| Obese | 9 | 21.11 | 14.8 | | |
| Total | 106 | 34.75 | 9.96 | | |

From the above table and the graph, the Mean Arch Angle of the Left foot of Normal and Underweight subjects are 37.29 and 38.89 respectively which is higher than overweight (32.55) and obese subjects (21.11) calculated by applying ONE WAY ANOVA TEST. "F" value is 9.90 and "p" value is <0.05 showing the significant change in the Arch Angle among the above groups

## DISCUSSION

In present study it has been shown the "Effect of body weight on Arches of Foot", by calculating PI(planter index) using Staheli`s planter arch index m The Mean Arch Index of the Right foot of obese and overweight subjects are 0.93 and 0.69 respectively, which is Higher than underweight (0.59) and normal (0.62) subjects by applying One wayANOVA test. "F" value is 7.31 and "p" value being <0.05 showing significant change among the classified groups. The Mean Arch Index of the Left foot of obese subjects are 0.97 and overweight subjects are 0.73, which is higher than underweight (0.62) and normal (0.61) subjects."F" value is 8.90 which are more than the right foot." P" value is <0.05 showing significant change in arch index among the groups The Mean Arch Angle of the Right foot of Normal and Underweight subjects are 38.27 and 37.11 respectively. This is higher than overweight (32.31) and obese subjects (21.89) calculated by applying ONE WAY ANOVA TEST. "F" value is 10.73 and "p" value is <0.05 showing the significant change in the Arch Angle among the groups.

The Mean Arch Angle of the Left foot of Normal and Underweight subjects is 37.29 and 38.89 respectively. This is higher than overweight (32.55) and obese subjects (21.11). "F" value is 9.90 and "p" value is <0.05 showing the significant change in the Arch Angle among the groups. The incidence of flatfoot in underweight subjects is 0%, 11.1% in normal subjects, 33.3% in overweight subjects and 55.6% in obese subjects.By comparing obese and overweight subjects with normal and underweight subjects, it is found that, obese subjects have less arch angle, showing increased incidence of Flat foot.

Study, conducted by Chen et al [10] studied 1024 subjects in 2009 for prevalence of flat foot in Taiwanese children. They observed incidence of flat foot 27% in normal wt, 31% in overweight, 56% in obese subjects. From this study the incidence of flatfoot in underweight subjects is 0%, 11.1% in normal subjects, 33.3% in overweight subjects and 55.6% in obese subjects. From the results I have obtained, it strongly proves the point of Chen et al the- arch index increases with increase in weight of an individual. Hence this study is similar to the study conducted byChen et al.

In another study conducted by Eklem Hastaliklari et al (2009),[11]observed the prevalence of flat foot in Turkish male adolescents and Correlation of flatfoot with weight and height were also evaluated. They found that the - Prevalence of flatfoot was found to be 0.69%. Correlation of flat foot with weight or height was not significant. But in this study conducted, correlation of flatfoot (arch angle and arch index) with height and weight (BMI) is entirely significant. This is because, all obese adult subjects were showing the presence of flatfoot. This study conducted disprovesEklem Hastaliklari et al's study.

In another study conducted by A.M. Dowling et al[12]entitled-Does obesity influences foot structure and planter pressure pattern in prepubescent children in 2001. Study was conducted on13obese and 13 non obese children. BMI, foot structure and planter pressure were collected. They observed that foot discomfort associated structural changes and increased forefoot planter pressure in obese foot may hinder obese children from participation in physical activity and therefore warrants immediate further investigation. Whereas this study compares the BMI with arch index and arch angle, where by conducting study on 106 adults, all the obese were showing the presence of flatfoot.

## CONCLUSION

BMI is significantly associated with Arch index

and Arch angle. Arch index is significantly higher in obese and overweight subjects than underweight and normal subjects. Arch angle is significantly higher in underweight and normal subjects than obese and overweight subjects. In the present study by comparing overweight and obese subjects with underweight and normal subjects, the obese and overweight subjects are more prone to have flatfoot. Simple Ink print method is cost effective, easy to apply and satisfactory for routine clinical examination. This method is non invasive and does not use radiation as well.

**Conflicts of Interests: None**

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