

## Correlation of Planter Arch index from Ink foot prints with BMI in medical students at Northern Border University Arar – A preliminary study

WAJID ALI CHATHA

Assistant Professor of Anatomy, College of Medicine, Northern, Border University, Arar 73551, Saudi Arabia.

Correspondence to Dr. Wajid Ali Chatha, Email: drchatha@gmail.com, 65, Chatha House, Lane No. 7, Gulistan Colony, Rawalpindi Cantt, Pakistan.

### ABSTRACT

**Background:** Obesity is becoming endemic in middle east and more and more people are falling in its trap due to the affluent life style of the middle eastern region. It was presumed that a direct correlation between the two if found may help us in outlining the people who will be more prone to obesity related complications. No such data had previously been found to be mentioned in the literature.

**Aim:** To calculate the plantar arch index and to compare it with the body mass index of the individuals.

**Study design:** A prospective study

**Methods:** An experimental and prospective study using medical students as the experimental subjects was designed. The study was conducted at Department of Anatomy at College of Medicine, Northern Border University, KSA. Study was conducted between the January to September 2019.

**Results:** Subjects' height and weight was recorded. Along it, their static ink-immersed foot imprints were obtained on the A4 size, pre-marked, white print paper. Obtained foot prints were scanned, printed and analyzed using "image J" software. The study parameters were analyzed using SPSS software. The study showed a strong and statistically significant correlation between the indices of foot arch and body mass.

**Conclusion:** A direct correlation between the foot arch and BMI was found. Information about the two indices may be used to predict the morbidity of several of the diseases currently affecting the affluent life styles, similar to the one prevalent in the Arabian Peninsula.

**Keywords:** Arch index, Body mass index, Medial plantar arch, foot arches.

---

### INTRODUCTION

Foot is a very important part of the skeleton for locomotion. It is beautifully and articulately designed to fit and adjust as per the contours of the ground. The articulated structure gives the foot its typical contour and hence the grip. Arches of the foot are very important in transmitting the weight of the individual to the ground so that one is able to maintain the balance while walking or standing, even on the uneven or rugged surface. These arches bear pressure points through which the major bulk of the weight is transmitted to the ground. As the foot is composed of bones of many different shapes and sizes, they are kept united by a lot of ligaments and muscles. They keep the bones in place and arches of the foot in shape, but the strength of ligaments and muscles do have their limit.

When the weight of the person crosses certain limits these arches may give way under the weight of the individual. One of the foot arches, named medial plantar arch, is the highest of the three arches of the foot. When it caves in, its shape under the force of the weight, the condition is termed as 'flat foot'. This is also the type of the foot that is commonly seen in the overweight / obese people.

Many studies were found to have been conducted to study the relationship of the foot structure and the body mass index (BMI). A gap of knowledge was found as none had tried to evaluate the 'direct' relationship between the two indices i.e., the foot arch index (AI) and BMI.

With the emergence of new scientific tools, foot prints have been studied using electronic plates that sense the pressure points of the foot and generate detailed digital

imaging of the foot with reference to one's weight bearing points. Nowadays pressure platforms are widely used in clinical analysis as they are easy to use and the measurements are easily and rapidly realized. Conventional footprints are still being used to assess the foot type using the ink or graphite powder.

High plantar foot arch has been attributed to several factors. They include the foot structure, ones walking strategy and normal body weight. It has been found that the biomechanics of the foot are influenced by the structure of the foot, primarily the medial longitudinal arch. Researchers have emphasized the need for the future work to involve and compare the healthy database to a demographically matched overweight group<sup>1</sup>.

In one study the effects of age and body mass index on plantar cutaneous sensation in healthy women were studied and used to predict the diseases of balance<sup>2</sup>. Another study was dedicated to evaluate the postural characteristics of the feet of older people and their relationship with their BMI. The obese women presented mean values for the AI significantly greater than those of the normal and overweight women. The authors concluded that obese women presented flatter feet while obese men presented more pronated feet, indicating a relationship between high BMI values and postural characteristics of the feet of subject's studied<sup>3</sup>.

In yet another study it was found that a consistent clinical association between higher BMI and plantar fasciopathy existed. The association may differ between athletic and non-athletic subgroups. Clinicians may utilize this information for collective decision-making when deciding about a certain foot pattern in sports medicine<sup>4</sup>.

Given this background knowledge the current study was designed to evaluate the hypothesis that arch index of an individual is directly proportional to one's body mass index.

**MATERIAL AND METHODS**

An analytical, quantitative and experimental study was designed to check the hypothesis. The scientific proposal was submitted to the Deanship of the scientific research of the Northern Border University, Arar, KSA for the approval and Ethical committee clearance. Once it was received in writing, the data collection was started. Confidentiality of the subjects was maintained thorough out the study.

The data collection involved recording the weight, height and foot imprint of the individual. Any person having any infection / injury to the foot was excluded in the study. Healthy volunteers were explained the rationale of the study which was to study the relationship between the foot pattern and body structure.

An A4 paper was designed to take the ink embossed foot imprints of the subjects. The paper had numbered square boxes of 1cm<sup>2</sup>, along with a space for writing the weight and height of the individual. An electronic weighing scale with the embedded stadiometer was used to record weight and height, respectively.

A 1.5inch deep foam pad was designed and made from locally procured material. This pad was pasted with pasting solution in a tray and soaked with routinely used office stamp ink. Verbal consent was taken from the subjects and procedure and purpose was explained to them completely, beforehand.

At the start of the experiment, weight was recorded in kilograms while the height was noted in centimeters for each individual. Body mass index (BMI) of the subject was then calculated and noted, using the following formula;

$$BMI = \frac{\text{Weight(kg)}}{\text{Height (cm}^2\text{)}}$$

Next, the subjects were asked to stand on the ink soaked foot-pad barefoot to properly soak the sole of their foot in the ink. They were then asked to step out of the foam pad and stand on the above mentioned A4 size paper. The ink imprints of the foot on the paper were then let to air dry.

Once dry, the precise outline of the foot imprint was then drawn by hand delicately by a dark marker. Next, to standardize the alignment, the long axis of the foot was marked and drawn on the paper. For this purpose the middle of the middle finger was used as reference. Using the mathematical square set, the extent of the foot area that needed to be calculated was marked. The long axis of the foot was then divided into three equal regions; using the same square set, perpendiculars were drawn to outline the three regions of the foot, namely; fore-foot (F), mid-foot (M) and rear or hind-foot (R) (Fig. 1).

Next, these papers were scanned in color at a high resolution. The scanned images were saved as JPEG files. These files were then opened in the "FIJI" image software which is an advanced version of the "ImageJ2" software. On the opened images, a fixed unit of length (3cm) was

standardized into the pixels. 714.0252 pixels equaled to 3cm when scaled and as calculated by the software. Using the free hand drawing tool of the image J software, the area for each divided region of the foot was calculated and mean reading was recorded in square centimeters. The plantar arch index of the foot (AI) for the each subject was then calculated by using the following formula;

$$AI = \frac{M}{F + M + R}$$

Where, F stands for fore-foot, M for mid-foot, and R for rear-foot area. The above equation is also known as Cavanagh index.

Recorded data was analyzed using SPSS software and p-values were calculated for the variables by applying the one sample t – test. A p-value of ≤ .05 was considered to give the significant difference between the results.

**RESULTS**

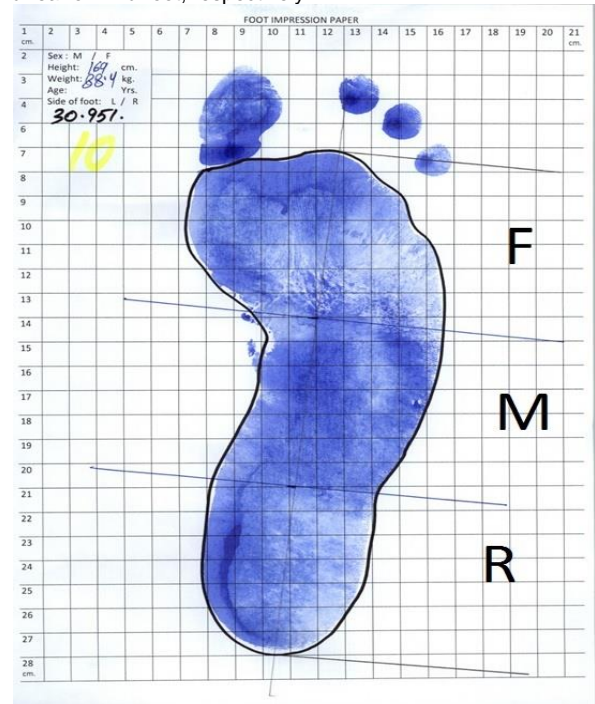
A total number of 49 male students had volunteered for the study. All the students were from the preclinical years of the MBBS program and participated on their own free will in the study. Analysis of the results showed that p ≤ .000. It predicted that a highly significant relationship existed between the two variables. (Table 1)

Table 1: Statistical analysis of study data using one sample t-test.

|                 | N  | Mean   | Std. Deviation | Std. Error Mean |
|-----------------|----|--------|----------------|-----------------|
| Body Mass Index | 49 | 27.266 | 8.997          | 1.285           |
| Arch Index      | 49 | 3.845  | 0.595          | 0.085           |

P value .000

Fig. 1: A scanned ink immersed foot imprint with the recorded data. F, M and R indicates the region and area of the fore-foot, mid-foot and rear or hind-foot, respectively.



## DISCUSSION

Obesity is becoming endemic in the Middle East due to the rich life style, higher incomes, affordability of lavish life style item and a sedentary life style. Junk food or fast food, as it may be called, is becoming the daily diet of the many due various social and cultural reasons in Arabia.

Prosperity with mechanization of the nations' brings with them the sedentary life style by which the morbid person can enter into a cascade of obesity, leading to but not limited to; hypertension, diabetes etc., and many associated diseases. The more markers we can identify for predicting the outcome of these and other diseases, the more beneficial it will be for clinicians to manage such situations.

In this study we tried to correlate the individuals' body size with the skeleton of the foot. Using these basic calculations, we may be able to turn this simple data into valuable predictors for impending risk factors of the diseases mentioned above. These are also categorized as diseases of lifestyle.

Researchers have been using the study of the structure of the foot for predicting the outcome of various diseases more recently. Authors reported that medial longitudinal arch height has important role in the postural balance of the middle aged women<sup>5</sup>. The comparison of the footprints obtained by various electronic methods has revealed significant differences of plantar arch index<sup>6</sup>. However, when author tried to use these plates, they were found to be very expensive and not many research centers could still afford them.

Some authors have reported that the study of anatomy and function of the foot's stabilizing structures has helped the radiologists to better understand some disabling disorders of foot like acquired flat foot deformity<sup>7</sup>. Others have tried to establish a relation between the quality of life with the foot arch pattern, however they failed to find a positive correlation between the two<sup>8</sup>. In one multi-central study from Pacific the authors discovered a new metric named the "mid-foot dorsal angle" to investigate the differences among various foot types<sup>9</sup>.

Given the work of previous researchers our study also corroborated the fact that very strong and positive correlation between the body weight of the individual with its structure exist.

As calculating both the indices does not require any specialized or expensive equipment, the relationship between the two calculated indices may be used to predict the outcome of various diseases associated with obesity. Author hopes that more refined easy to use tools may develop over a period of time.

## CONCLUSION

The study has verified the hypothesis that body mass index and arch index of the foot of the individual are directly related to each other.

**Conflict of interest:** The author declares no conflict of interest whatsoever for the study.

**Funding:** This was a funded project by the deanship of the Scientific research of the Northern Border University Arar, Kingdom of Saudi Arabia to promote research. However, the author pledges no bias in the study due to financing of the study.

**Acknowledgements:** The author wishes to thank Dr. Amgad Nyazy Elsayy and Mr. Hassan Mohammad Iqbal for their abundant and enthusiastic help during the course of the project. Both are working as lectures at the same place as that of the author.

## REFERENCES

1. O'Brien DL, Tyndyk M. Effect of arch type and Body Mass Index on plantar pressure distribution during stance phase of gait. *Acta Bioeng Biomech* 2014; 16(2):131-5.
2. Yümin ET, Şimşek TT, Sertel M, Ankaralı H. The effect of age and body mass index on plantar cutaneous sensation in healthy women. *J Phys Ther Sci* 2016; 28(9):2587-2595.
3. Aurichio, Thais, Rebelatto, José, Paiva de Castro, Alessandra. The relationship between the body mass index (BMI) and foot posture in elderly people. *J. archger* 2010; 89-92.
4. Van Leeuwen KDB, Rogers J, Winzenberg T. Higher body mass index is associated with plantar fasciopathy/plantar fasciitis: systematic review and meta-analysis of various clinical and imaging risk factors. *Br J Sports Med. Br J Sports Med* 2016; 50(16): 972-81.
5. Karataş L, Vurallı D, Günendi Z. The effect of medial longitudinal arch height and medial longitudinal arch support insoles on postural balance in perimenopausal women. *Turk J Med Sci* 2019; 18;49(3):755-760.
6. Tascau MT, Vigaru C, Pasca O, Stoia DI, Bălănean F., Comparison of Plantar Arch Index Calculated from Ink and Electronic Footprints, *Key Eng. Mater* 2014; 583, 125-128.
7. Flores DV, Mejía Gómez C, Fernández Hernando M, Davis MA, Pathria MN. Acquired Flatfoot Deformity: Anatomy, Biomechanics, Staging, and Imaging Findings. *Radiographics* 2019; 39(5):1437-1460.
8. Daniel López-López et al. Foot Arch Height and Quality of Life in Adults: A Strobe Observational Study. *Int J Environ Res Public Health* 2018; 15(7): 1555.
9. Xiong S, Goonetilleke RS, Witana CP, Weerasinghe TW, Au EYL. Foot Arch Characterization A Review, a New Metric, and a Comparison. *Journal of the American Podiatric Medical Association* 2009; 100. 14-24.