ORIGINAL ARTICLE

Studying relationship between the area of mid-foot region and Body Mass Index

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ABSTRACT

Aim: To find a relationship between midfoot surface area and the body mass index.
Study design: A prospective, experimental, qualitative study
Methods: An experimental study was designed using medical students as the experimental subjects. The study was conducted at College of Medicine, Northern Border University, KSA. Study was conducted between the January to September 2019. 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.
Results: The study showed a strong and statistically significant correlation between the midfoot surface area and body mass index.
Conclusion: A positive correlelation exists between the midfoot surface and the the body mass index of the same individual.
Keywords: Body mass index, Chopart joint, Mid foot area, Obesity, Surface Area.

INTRODUCTION

The human foot is an incredibly complex part of the body, composed of 26 bones; 25% of the total number of bones in the whole body. The foot plays a definite role in the human body, in that walking capacity is necessary to carry out daily activities[1]. The foot receives pressure equal to approximately 80% of body weight with each step. Foot is sometimes referred to as the second heart because it augments in pumping up blood[2]. Not only they support the body weight while standing or walking, but also maintain body balance against external shock[3].

The foot is anatomically divided into three major structural areas: the forefoot, the midfoot and the hindfoot[4]. The junction between the hind and midfoot is called the *Chopart* joint complex, which includes the heel and calcaneocuboid joints[5].

The body mass index, or BMI, is a measure of body size metric. It incorporates the weight and height of an individual. BMI measurement results '*may*' give an idea as to whether a person has the right weight for their height. BMI can also be used as a screening tool that can predict whether a person is underweight, healthy or falls into the category of obesity. If ones' BMI is outside the healthy range, it can significantly increase the health risks.

Several studies have been conducted in the past to study the relationship between the foot structure and the body mass index (BMI). Although the ones that studied a relationship between the individual foot areas and body mass index were scanty. Most of these studies have shown a certain relationship between the foot arches and the BMI[6] The author found and presents his data in this paper as a part of a continuous research studying the foot arches and relationship with the weight of the individual.

MATERIAL AND METHODS

The study shares the same material and methods as that of its prinicipal project[6]. An analytical, quantitative and experimental study was designed and Ethical clearance obtained from the Deanship of the scientific research of the university. Data collection was started soon after. Identity of the subjects was kept confidential thorough out the study.

We needed to record the weight, height of the subjects and had to take a foot imprint of the individuals too. We excluded the subjects that had any infection or injury to the foot. Students volunteering to be part of the study were explained the rationale of the study beforehand.

A pre-designed A4 paper was used to take the ink embossed foot imprints of the subjects. The paper had numbered square boxes of $1cm^2$. All the data of a subject was recorded on the same sheet. An electronic weighing scale with an attached stadiometer was used to record weight and height, respectively.

To take the ink embossed foot impression, we designed a 1.5inch deep foam pad. This pad was pasted with pasting solution in a tray and soaked with routinely used non-toxic 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;

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

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) (Figure 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 $3cm^2$ when scaled and as calculated by the software. Using the free hand drawing tool of the image J software, the area for mid foot region was calculated and mean reading was recorded in square centimeters.

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 datapredicted that a very high probability is there for the direct relationship between the midfoot area and the BMI. It predicted that a highly significant relationship existed between the two variables. (Table 1)

Figure-1

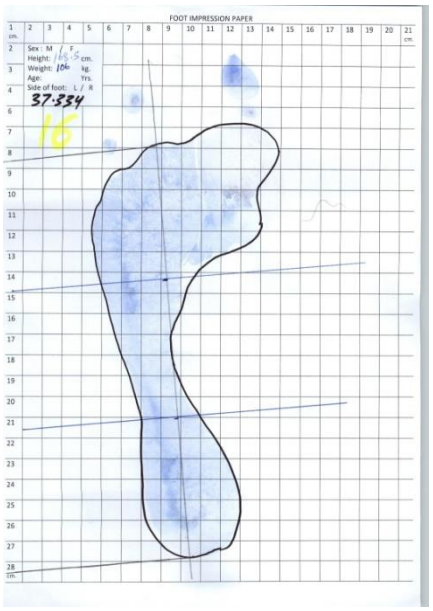

Table 1: One-Sample Test

	N	Mean	S.D	SEM
Body Mass Index	49	27.27	9.00	1.29
Mid Foot Area	49	31.35	9.89	1.41

P value ≤.05

DISCUSSION

To our knowledge, this is the first study to identify a significant longitudinal relationship between higher BMI and surface area of midfoot and is novel to report midfoot surface area results in students of northern border university. Furthermore, this investigation showsthat overweight students and, not only, obese students, display greater midfoot contact with the ground.The purpose of this investigation was to understand the interaction between the midfoot surface area and BMI. Regarding the mid-foot area, our current knowledge[7,8,9] indicates that in the early ages of independent walking this area is filled with a fat pad and this structure is used to alleviate the concentration of pressure caused by the dramatic increase in body weight before the end of the development of the foot arch. Hennig et al[10] suggested that the mid-foot was the main loading area in the foot arch;

High BMI had already been correlated with foot problems in some of the previous studies[11,12].It has been proposed that excessive mechanical loading has an effect that could lead to joint damage in the midfoot area of the foot.

The data gathered in this study show that mid foot contact area of the obese students differ significantly from those of overweight students and ones with a healthy weight. Also worthy of consideration is the role of the midfoot in producing or absorbing power at the level of body center mass.

Our study provides unique insight into the unique relationship of the mechanical function of the surface area of the midfoot with BMI.The findings suggest that overweight / obese students display foot dimensions that are significantly greater than those of non-overweight students.

The overweight/obese students in this study displayed larger foot lengths, breadths, and circumferences. That is, as all other foot dimensions recorded for the overweight/obese were greater when compared with their leaner counterparts. It is postulated that these structural changes, which may adversely affect the functional capacity of the midfoot surface area, might be exacerbated if excess weight bearing continues throughout adulthood. Therefore, urgent interventions, which take into consideration the unique structural characteristics of overweight and obese students, are required to prevent further weight gain and structural and functional complications to their feet.

This study aimed to determine the extent, the surface area and associated factors of BMI among students of northern border university and the findings need to be considered in the context of several limitations. Finally, the key limitation of all cross-sectional studies is the inability to confidently infer causation. Results from the current study provide evidence that the area of the midfoot and BMI have a significantly positive relationship.

This studyalso highlights the importance for early detection of focusing on midfoot problems in routine clinical care, together with physical and radiographic examination. Early detection of foot involvement can reduce disability through early treatment.

CONLUSION

The author believe that the relationship between flat feet, increased loading of the midfoot surface area described here is plausible and warrants further investigation in prospective studies. Future studies exploring the relationship between midfoot surface area and BMI are indicated and we shall try to continue them in our laboratories.

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