ORIGINAL ARTICLE

Assessing Association between Body Mass Index and Forefoot Area

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ABSTRACT

Aim: To find a functional or anatomical correlation between the fore foot area, height and weight of an individual.
Method: A prospective experimental study medical students of preclinical years were recruited into the study and their foot prints were taken on a predesigned A4 sized paper. Foot was divided by geometrical tools into three regions; forefoot, midfoot and hindfoot area. Area of the forefoot was calculated using the specific image-J software after standardizing the metric units into pixels.
Result: Analysis through SPSS shows a strong relationship between the parameters.
Conclusion: Simple parameters can be defined using simpler techniques to predict the outcome of lifestyle induced diseases.
Keywords: Body mass index, BMI, Forefoot, Forefoot area, foot arch, obesity

INTRODUCTION

The foot is lowermost part of the body which carries weight; structure of bones, muscles, and joints enables movement during standing and walking by absorbing and supporting intense pressure. Despite the initial overthrow of Cavanagh et al 's' tripod' theory of load distribution (three points where the foot touches the ground) in 1987[1], based on the definition of human anatomy as well as the research provided by Taha et al. in 2016[2], it appears that physiologically there are three key points with the highest load on the sole: the central part of the heel and the 1st and 4th -5th metatarsal heads.

Human foot morphology is an important topic in many biomedical disciplines for physical anatomical study, including orthopedics, orthotic architecture, and sports sciences. Various conditions and daily behaviors (e.g., frequency of athletic activities, shoe wearing behaviors) as well as personal characteristics such as age, sex and body mass index have been shown to have a major impact on adult foot morphology[3].

The feet transmit to the ground the body weight and retain the balance of stance during locomotion. The feet serve as a shock absorber during the foot strike and then become the lever for push-off[4]. The related muscles, tendons, or ligaments are vulnerable to injury because the feet bear the weight of the entire body. Foot conditions impede ambulation and make the quality of life of patients worse[5]. Foot pain can result from tendon sprain, stress fracture, arthritis, interdigital neuroma[6] and intrinsic muscle disorders[7].

Adequate foot safety enables any workout that is done under load. Together with other balanced lifestyles, physical activity is the primary public health policy aimed at preserving good health and preventing disease. Distance running is currently a common and increasingly popular physical activity designed to improve both physical and mental health[8].

Flatfoot deformity is a complex foot deformation with various elements, such as medial longitudinal arch collapse, hindfoot valgus and forefoot abduction[9].

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The influence of personal characteristics (e.g. body mass index, sex, age) on the foot shape are also investigated. In this paper, the author presents his data as a part of a continuous study of foot arches and forefoot surface area relationship with the individual's weight.

The current paper evaluates another hypothesis that an individual's forefoot surface area is directly proportional to one's body mass index in the given context information.

MATERTIAL AND METHODS

A theoretical, quantitative and experimental analysis was planned to verify the hypothesis. The scientific proposal was submitted for approval to the Ethical Committee. The data collection began once it was collected in writing. The subjects' confidentiality was thoroughly protected in the report. The data collection included documenting the individual's weight, height and foot imprint. In the data collection, any person with any infection / foot injury was excluded. The rationale of the research; to investigate the relationship between the foot pattern and the structure of the body, was clarified to the volunteers. The procedure obtained verbal consent and the intention was thoroughly explained to them, beforehand. To take the ink embossed foot prints from the subjects, an A4 paper was made. In addition to a space for writing the weight and height of the person, the paper had numbered square boxes of 1cm^2. To record weight and height, respectively, an electronic weighing scale was used with the embedded stadiometer.

A 1.5 inch deep foam pad was used as stamping pad. This pad was pasted into a tray with pasting solution and soaked with office stamp ink, used regularly. Weight was measured in kilograms at the beginning of the experiment, while height was noted in centimeters for each person. The subject's body mass index (BMI) was then measured and noted using the formula below.

$$\textbf{BMI} = \frac{\text{Weight (Kgs)}}{\text{Height (CM}^2\text{)}}$$

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

When dry, the exact outline of the footprint was then delicately drawn by hand with a dark marker. First, the long axis of the foot was marked and drawn on paper to standardize the alignment. The middle of the middle finger was used as a guide for this reason. The extent of the foot area that needed to be measured has been marked using the mathematical square package. The long axis of the foot was then split into three equal regions; the perpendiculars were drawn using the same square set to outline the three regions of the foot, namely: fore-foot (F), mid-foot (M) and rear or hind-foot (R) (Fig. 1).

Next, at a high resolution, these papers were scanned in color. They saved the scanned images as JPEG files. In the "FIJI" image software, which is an advanced version of the "ImageJ2" software, those files were opened. A fixed unit of length (3 cm) was standardized into the pixels on the opened images. The area for each divided region of the foot was measured using the free hand drawing tool of the image-J program and the mean reading in square centimeters was registered.

Using SPSS tools, reported data was analyzed and p-values were determined by applying a single sample t-test for the variables. The important difference between the findings was known to be a p-value of 0.05.

RESULTS

Extrapolation of the data using SPSS showed a strong correlation between the two parameters. The calculated p - value was < .05. The mean BMI was closer to, but slightly above the normal. The forefoot area was found to have a low deviation from the mean and hence significant. (Table-I)

Different areas of the foot delineated: Forefoot consists of metatarsal and phalanges; midfoot comprises of three cuneiforms, navicular and cuboid; while the talus and calcaneus form the hindfoot skeleton[16].

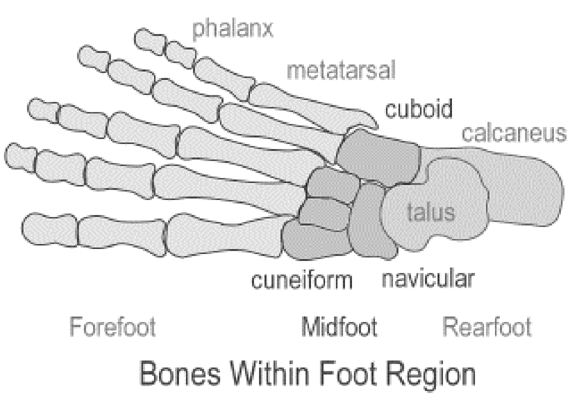

Fig. 1

Table 1: One sample statistics

	N	Mean	Std. Deviation	Std. Error Mean
Body Mass Index	49	27.28	8.98	1.28
Fore Foot Area	49	51.06	7.04	1.01

P value <.05

DISCUSSION

Prosperity with the mechanization of nations brings with it the sedentary lifestyle in which the morbid person will enter a cascade of obesity, contributing to, but not limited to; hypertension, diabetes, etc., and many related diseases. The more indicators we can recognize to predict the outcome of these and other diseases, the more effective clinicians can be in treating these circumstances[10].

Due to the affluent environment, higher incomes, affordability of luxury lifestyle products and a sedentary lifestyle, obesity in the Middle East is getting rampant. Junk food, misnomered as fast food, is becoming a vogue and becoming another norm of the society. Same diseases but a new class of patients has emerged in the recent past that can be termed to be suffering from the lifestyle diseases.

This study investigated associations between weight status and normal plantar surface area among youth. The limitation of this study is that the number of participants is not enough. In our study we have attempted to equate the body size of the individuals with an important functional and anatomical part of the foot skeleton in this study. We expect that we can turn these simple data into useful predictors for the imminent risk factors of the diseases mentioned above using basic calculations. A disruption in standing and walking mechanics is the result in pathological modifications in the feet.

In a group of students we applied geometric morphometric methods to analyse footprint shape variability. A complete collection of landmarks and semi landmarks represented the outline of the feet, including the toes, allowing for a precise morphological study without any previous selection of shape features. The first four key components of footprint shape-the major axes of differentiation-reflected critical aspects of foot morphology: low arched versus high arched feet, long and narrow versus short and broad feet, the relative length of the hallux, and the relative length of the forefoot. These shape characteristics differed independently throughout the individuals measured, with no distinct clusters or discrete footprint shape forms. The distinction between different types of foot, which is very common in the literature,[11] therefore, remains partly arbitrary: the concept of foot types cannot be completely based on biological variability, but must be constructed for particular purposes, such as shoe development or clinical care. It is impossible that different typological structures based on common parameters would correlate.

Broad and flat feet were correlated with a high BMI which other researchers also noticed. Ashizawa et al[12] and Mauch et al[13] for example, registered an improvement in relative foot width by body weight.

There are five toes on all primates. However, aside from humans, the first toe of all primates is divergent. Humans have shorter, non-divergent toes, the most common bipeds in the primate order, as the prehensile function is less significant[14]. Bipedal locomotion allows the foot to act as both a foot strike shock absorber and a push-off lever. The human foot is built with a lever arm and a load arm, connected by the plantar aponeurosis, to accomplish this. This forms the 'windlass mechanism' which Hicks first described in 1954[15].

Clinically, this finding implies that barring progressive metabolic changes that may precipitate type II diabetes and associated neuropathy, youth with obesity. Further clinical studies on patient populations are needed to validate these conclusions, as well as to determine whether and how they can be precisely applied to different populations. Our findings could prove valuable in various areas of application.

The weaknesses of this study are its retrospective design and limited sample size. However, despite these limitations, the results of this study provided preliminary information for future prospective, randomized clinical trials with larger samples. In addition, to the best of our knowledge, this is the first study defining the forefoot surface area and correlating it with the height and weight of the individual.

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