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Relationship of Body Weight with the Foot Shape of Adult Bangladeshi Male Medical Students: An Anthropometric Study

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ABSTRACT

Foot shape significantly varies with age, sex and ethnicity. Information on gender and racial differences in foot shape is also useful to forensic scientists identifying isolated remains. Literature survey revealed that there are not enough studies on correlation of foot shape with changes in body weight. Hence this cross-sectional and analytical study was carried out to evaluate the correlation of foot shape with changes in body weight within same race and ethnicity. A total number of 110 male medical students of 3rd and 4th year of Bengali ethnicity were chosen through purposive sampling. Foot index was calculated by dividing the foot length with the foot width. On the basis of foot index, foot shapes were classified into slender, standard and broad. Correlation of the foot shape with the body weight was assessed. Both right and left foot indices showed significant negative correlations with the body weight ($r = -0.214$, $p = .033$ and $r = -0.282$, $p = 0.005$ respectively). This approach of categorization will help in making best fit footwear for males. It will also serve as a baseline data for forensic investigators.

Keywords: body weight, forensic anthropometry, foot index, foot shape

INTRODUCTION

Foot shape is the outline of a foot contour projected on the plane in standing posture. It contains information on the morphological characteristics of the foot that cannot be represented by conventional variables such as dimensions, angular measurements and proportions. Persons having same foot length and width may not have similarity in foot shape. The shoe manufacturers analyze outline of foot to construct a morphology-based strategy for improving the fit between the foot and shoe[1]. Wearing ill-fitted shoes leads to foot disorders, mental impacts, comfort reduction, increasing energy consumption and decreasing the subject efficiency for doing tasks[2]. It is commonly recognized that correct shoe fit is attained by matching shoe shape to the shape of the foot[3]. Reliable and definitive data of foot shape is essential in the manufacture of ergonomic shoes[4]. Depending on the similarities, categorization of foot shapes into different types can be helpful for the shoe designers in the shoe industry[5].

Foot shape significantly changes with age, sex and ethnicity[1]. Information on gender and racial differences in foot shape is also useful to forensic scientists identifying isolated remains[6]. Establishing the identity of an individual from mutilated, decomposed and amputed body fragments has become an important necessity in recent times due to natural disaster like earthquakes, tsunamis, cyclones, floods and man-made disaster like terror attacks, bomb blasts, mass accidents, wars, plane crashes and so on[7]. Systematic analysis of foot shape variation is necessary to identify the causes of misfit and to establish an objective method to modify a shoe to fit the feet of different shapes[1]. An understanding of morphological and functionality of variation in footwear among ethnically different populations thus necessitates a basic understanding of ethnic variation among populations using similar footwear[8].

Literature survey revealed that there were not enough studies on correlation of foot shape with changes in body weight. Hence the present study was designed to evaluate the same within same race and ethnicity. The study also serves as a database for the forensic specialists, a normative reference for the anatomists and an aid for diagnosis to the podiatrists.

MATERIALS AND METHODS

This was a cross-sectional and analytical study. It was carried out between July 2010 and June 2011 in the Department of Anatomy, Sir Salimullah Medical College, Dhaka after getting permission from the institutional ethics committee (SSMC/IEC:2010/7). A total number of 110 male medical students of 3rd and 4th year of Bengali ethnicity were chosen through purposive sampling.

At the beginning of the study each subject was greeted politely. Then they were informed about the total plan of the study, its implications and about the entire spectrum of benefits and potential risks. Written consent was obtained from the subjects. They were requested to stand straight on the weighing machine on bare feet and the weight was recorded. Then the subjects were requested to stand on a stool bearing weight on both equally balanced feet. The foot length was measured using a foot callipers. It was measured when the ankle was perpendicular to the foot. The fixed jaw of the callipers was placed on pterion (most posterior and prominent point of the heel) and the sliding jaw was fixed on acropodion (tip of the most protruded first or second toe) (Fig.1a). The callipers were kept parallel to the long axis of the foot. Maintaining the same posture and condition, the width of the foot was measured. The sliding and fixed jaws of the callipers were placed respectively on metatarsal-tibiale and metatarsal-fibulare of the foot (Fig.1b)[8]. Length and width of both right and left feet were measured, using the formula: Length/width = reading of the main scale + vernier coincidence × vernier constant + mechanical error (Here vernier constant = 0.01 and mechanical error = 0)[9].

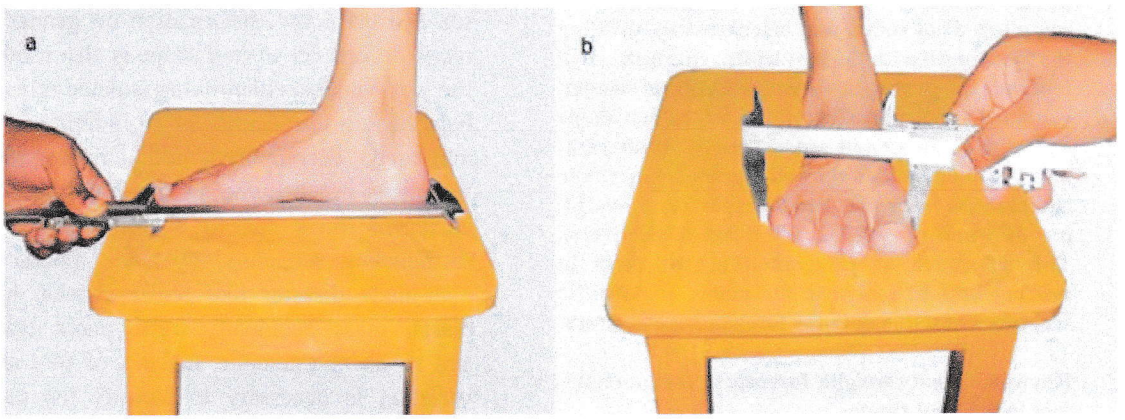

Figure 1 Procedure for measuring foot length (a) and foot width (b) by foot callipers.

The procedure was carried out between 10 am to 2 pm to avoid any diurnal variations. Foot index was calculated by dividing the foot length with the foot width (Foot index = Foot length / Foot width)[10]. Mean and standard deviation for the foot index were calculated.

According to the foot index three types of foot shapes were determined and classified into slender ($FI' < FI - SD$), standard ($FI - SD < FI' < FI + SD$) and broad ($FI' > FI + SD$) where FI', FI and SD indicated individual foot index, mean foot index and standard deviation respectively[10]. Correlation of the foot shape with the body weight was assessed using SPSS version 16.0 program (2011).

RESULTS

Body weight of the subjects ranged from 47.5 kg to 79 kg. The calculated foot index on the right side was between 2.28 and 2.99 whereas on the left side was between 2.30 and 2.98 (Table-1). Out of 110 students 70% had standard shaped right foot and 62% had standard shaped left foot (Table-1).

Both right and left foot indices showed significant negative correlations with the body weight $r = -0.214$, $p = .033$ and $r = -0.282$, $p = 0.005$ respectively (Figures 2 and 3).

Table 1 Classification of foot shape according to foot index.

Variables	Number	FI (Mean ± SD)	Type of foot shape		
			Slender	Standard	Broad
			FI′<FI-SD	FI-SD< FI′<FI+SD	FI′>FI+SD
Right foot	110	2.58± .14	13%	70%	17%
Left foot	110	2.57± .13	21%	62%	17%

(FI′= Individual foot index, FI= Mean foot index, SD= Standard deviation)

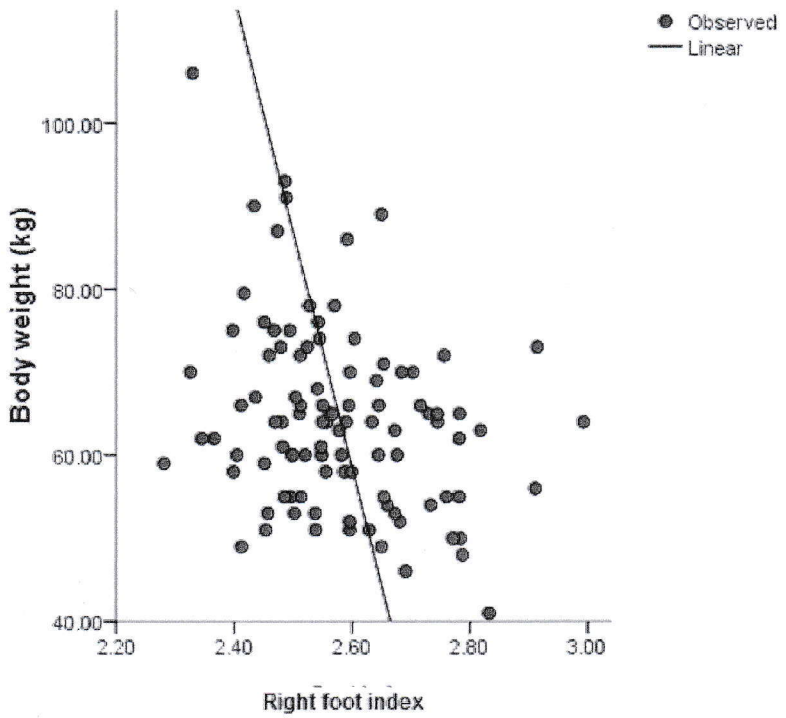

Figure 2 Scatter diagram with regression analysis showing significant negative correlation between the body weight and the right foot index ($r = -0.214$ and $p = 0.033$).

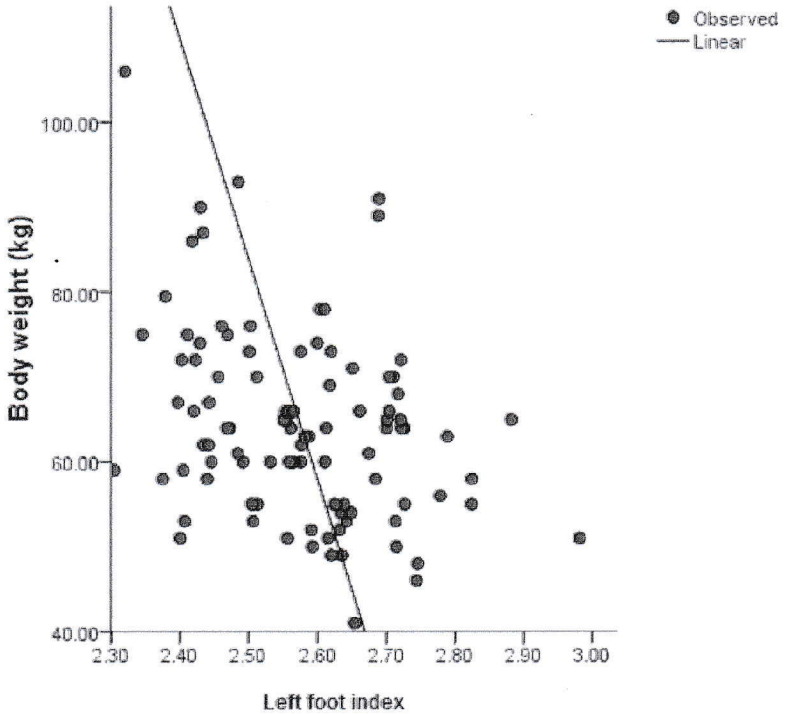

Figure.3 Scatter diagram with regression analysis showing significant negative correlation between the body weight and the left foot index (r = –0.282 and p = 0.005).

DISCUSSION

Anthropometric analysis of body parts contributes a lot for gait of individual and scientific investigations as well. The purpose of the study was to show the relationship between body weight and foot shape. This may provide the forensic scientists the best (or only) opportunity to predict that aspect of a victim or suspect's physical description. In this study the foot index decreased with increased body weight. This indicates a person with more body weight would have a broad shaped foot. There is paucity of literature regarding relationship between body weight and foot shape and this may be first report in this aspect.

It has been shown that even during adolescence, gender and stature can be predicted more accurately from foot measurements than that from the long bones of the lower limb[11]. Kayano (1986) and Umeki (1991) found that the medial arch length changed at different phases of gait[12, 13]. Olapido et al. (2008) found that the foot length and foot breadth of male in relation to full-body weight increased[14]. The foot shapes corresponding to different weight bearing conditions are believed to be unique and can provide a more comprehensive description of the foot-insole interaction for the making of ergonomic shoes[15].

Frequency distribution of different foot shapes, in this study differ with Jung et al. (2001)[10] where the percentage of standard shaped foot was higher (about 20% for the right foot and 5% for the left foot) than that of the present findings. The difference may be due to the ethnic variation. However, in both the studies percentage of standard shaped foot was higher in comparison to the other foot shapes. This data would act as a reference for the anatomists and podiatrists.

This study focused on qualitative descriptions of foot shape only and the kinematic aspects were not addressed. Moreover, sample size and sampling technique adopted in the

study were not enough to substantiate on representative population.

The significant negative correlation between body weight and foot shape implicates that this approach is applicable to a large sample and has a great potential to construct a baseline data of foot shape of different age groups, sex, ethnicity and forensic investigations.

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