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Original Article

An Autopsy-Based Correlation Study about Developing Standards for Estimation of Stature from Foot Anthropometry in Male Population of Central India Region (Indore, MP)

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ABSTRACT

Identification of an individual is very important in criminal cases like assault, murder, rape, disputed paternity and impersonation, and in civil cases like marriage inheritance and disputed sex. Estimation of stature from extremities and their parts play an important role in identifying the dead body in forensic examinations. The aim of this study was to find the correlation between foot anthropometry and stature of an individual and to derive regression formula to estimate the stature from foot anthropometry in the Central India population. This cross-sectional study was carried out on 250 deceased males of age 21 years and above brought for post-mortem examination in mortuary of Forensic Medicine Department, M.G.M. Medical College and M.Y. Hospital, Indore (MP).The mean right foot length and left foot length was 23.58±1.86 cm and 24.55±16.44 cm, respectively, whereas mean stature was found to be 163.39±5.26 cm. Mean foot breadth for both right and left foot was found to be 8.14±0.52 cm. In this study, maximum stature in males was found to be 179.5 cm, whereas minimum stature was found to be 153.1 cm. The correlation between foot length and stature was found to be to be better predictor of stature than foot breadth. As the first step in forensic analysis is establishing the identity of the person in question, where stature remains one of the primary characteristics for identification. So the findings of this study is useful for forensic experts and anthropologists.

Keywords: Identification, anthropometry, stature, foot length

INTRODUCTION

Identification of individual is the mainstay of forensic investigations. Age, sex, stature and race are popularly referred to as the four pillars of identity of a person. Among these 'big fours' of forensic anthropology, estimation of stature and sex is considered as one of the main parameter of personal identification in forensic examinations. In the recent times, due to natural disasters like earthquakes, tsunamis, cyclones, flood and manmade disasters like terror attacks, bomb blasts mass accidents and war plane crashes it is important for both legal as well as humanitarian reasons. In medico-legal autopsies, establishing personal identity of the victim is often required.

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Anthropometry is the systematic measurement of the physical properties of the human body, primarily dimensional descriptors of body size and shape [1,2]. It is the single most portable universally applicable inexpensive and non-invasive technique of assessing the size, proportion and composition of the human body. Anthropometry helps in reconstruction of the biological profile of the deceased such as age, sex, ethnicity and stature [3].

Stature is an important measure of physical identity. Human height is the vertical distance from the bottom of the feet to the top of the head in standing erect position[4]. Stature is defined, as 'The vertical distance between the highest point of vertex and the heel touching the floor'[5].

In medico-legal autopsies, establishing personal identity of the victims is often required. Estimation of stature and sex from extremities and their parts plays an important role in identifying the dead body in forensic examinations. In the past, many studies have been conducted on estimation of stature from various measurements on different parts of human body. The relationship between humerus, radius, ulna, femur, tibia, fibula and clavicle with the stature has been topics of research interest for decades.

Ossification and maturation in the foot occurs earlier than the long bones and therefore, during adolescence age and height could be more accurately predicted from foot measurement as compared to that from long bones. Morphology of human feet is greatly influenced by the combined effects of heredity and living style of man that determines the size and shape of the feet footprints and thereby makes them unique data to establish human identity. Clinicians, anthropologists, anatomists and forensic scientists have studied the various aspects of foot, over a long period of time.

The study aimed at determining the correlation of various measurements of the feet with stature. Linear regressions for estimation of stature have been derived to suit the Central Indian population. The data presented in this study will be of extreme benefit for fellow researchers in forensic science, investigators and legal experts to aid in stature determination of a person from the dimensions of the feet.

The aim of this study was to find the correlation between foot anthropometry and stature of an individual and to derive regression formula to estimate the stature from foot anthropometry in males in the Central India population.

MATERIAL AND METHODS

This cross-sectional study was carried out on a sample of 250 deceased males in mortuary of Department of Forensic Medicine, Mahatma Gandhi Memorial Medical College and M.Y. hospital, Indore (MP). In this study, convenient sampling procedure was done. Study subjects are all male cases of post-mortem examinations of age more than 21 years. Subjects with skeletal abnormalities, deformities, amputated lower limbs, mutilated and decomposed body were excluded. Written informed consent was taken prior to the research after giving detailed information to the relatives of the subjects regarding the study.

Firstly, detailed history was taken both regarding the incident and complete clinical history including operative procedures. Detailed individual demographic data including the height, sex and age were also recorded on the pre-structured proforma. Anthropometric measurements of the foot viz. foot length and foot breadth were taken independently on the left and right side of each individual. Stature of each subject was also recorded. All the measurements were taken in daylight. The measurements were taken twice for accuracy. The measurements were taken using standard anthropometric instruments in centimetres to the nearest millimetres. Proper care has been taken to avoid any excessive compression of underlying tissues and to record the measurement precisely.

Stature is measured as the vertical distance between the vertex and the heel in mid sagittal plane, where the vertex is the highest point on the head when the head is held in Frankfurt Horizontal (FH) plane using standard measuring tape.

Foot length is measured as the distance from the most prominent part of the heel (Pternion) backward to the most distal part (Acropodion) of the longest toe (second or first) using sliding calliper.

Foot bread this measured as the distance between the points of the anterior epiphyses (distal) of the first metatarsal, the most prominent of the inner side of the foot (Metatarsal-Tibiale), and the joint of the anterior epiphyses of the fifth metatarsal, the most prominent of the outer side (Metatarsal-Fibulare) using sliding calliper. Foot Index was calculated by foot breadth divided by foot length and multiplied by 100.

The mean values and standard deviation (SD) of foot dimensions were calculated. Statistical analysis was carried out using IBM SPSS Statistics (version 2015) software package to calculate linear regression equations and compute multiplication factor. Pearson's correlation coefficient was calculated to establish the correlation between the stature and the foot dimensions. Paired sample *t*-test was performed to find the right and left side differences in foot dimensions. *p*-value of less than 0.05 was considered as significant.

RESULTS

This study was carried out on a sample of 250 deceased males in mortuary of Department of Forensic Medicine, Mahatma Gandhi Memorial Medical College and M.Y. hospital, Indore (MP).Table 1 shows age-wise distribution of the study subjects. In this study, mean age of the study subjects was found to be 39.91±13.41 years. Maximum number of cases were in age group of 21–25 years (18.0%), whereas minimum number of cases were in age group 70–75 years and 85–90 years (0.4%).

Table 2 shows mean stature in subjects was 163.40±5.26 cm. In this study, maximum height reported was 179.5 cm whereas minimum height was 153.10 cm. Table 3 shows the statistical analysis for foot length in study subjects (Figure 1). It shows that mean foot length on right side (23.58±1.87 cm) are less than mean foot length on left side (24.55±16.44 cm) in subjects. This can be attributed to effect of foot dominance on foot measurements. In this study, maximum foot length was 27.50 cm, whereas minimum foot length was 19.50 cm

Table 1: Age-Wise Distribution of Study Subjects

S. No.	Age group (years)	No. of cases	Percentage
1.	21–25 years	45	18.0
2.	25–30 years	43	17.2
3.	30–35 years	25	10.0
4.	35–40 years	33	13.2
5.	40–45 years	28	11.2
6.	45–50 years	22	8.8
7.	50–55 years	20	8.0
8.	55–60 years	18	7.2
9.	60–65 years	10	4.0
10.	65–70 years	4	1.6
11.	70–75 years	1	0.4
12.	75–80 years	0	0.0
13.	80–85 years	0	0.0
14.	85–90 years	1	0.4

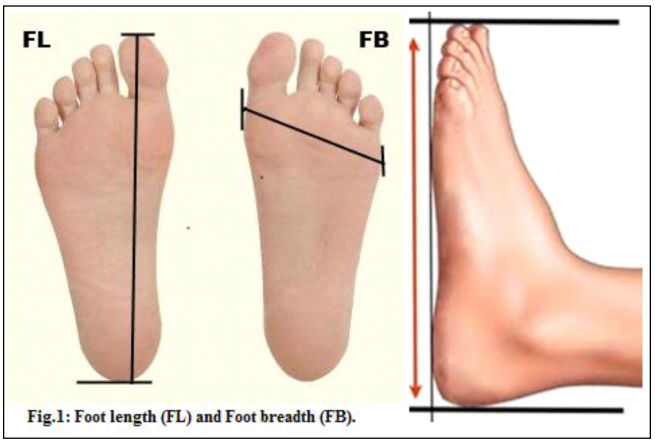

Figure 1: Showing Landmark Points of the Foot Length and Foot Breadth

Table 2: Distribution of Height among Study Subjects

Variables	Mean	Standard deviation	Maximum	Minimum	Range
HT in cm	163.40	5.26	179.50	153.10	153.10–179.50

Table 3: Statistical Analysis for Foot Length in Study Subjects

Variables	RFL (cm)	LFL (cm)	Av. FL (cm)
Mean	23.58	24.55	23.34
SD	1.87	16.44	2.06
Maximum	27.50	28.20	27.50
Minimum	19.50	19.20	17.55
Range	19.50–27.50	19.20–28.20	17.55–27.50

on right side and the range was from 19.5 to 27.5 cm, whereas maximum foot length was 28.20 cm and minimum foot length was 19.20 cm on left side and the range was from 19.20 to 28.20 cm. In this study, average foot length was found to be 23.34±2.06 cm. Maximum average foot length was 27.50 cm whereas minimum foot length was 17.55 cm.

Table 4 shows the regression equation of right foot length with stature. The equation obtained is 113.83 + 2.102 RFL, 114.34 + 2.087 LFL and 125.24 + 1.635 AvFL, shows that by putting the value of RFL, LFL and AvFL in the equation stature can be measured.

Table 5 shows statistical analysis for foot breadth in study subjects. The table shows that foot breadth on right side (8.12±0.55 cm) was more than on left side (8.04±0.54 cm) in study subjects. In this study, maximum right foot breadth was 9.40 cm and minimum was 6.70 cm, whereas maximum left side foot breadth was 9.30 cm and minimum foot breadth was 6.70 cm. Average foot breadth in male subjects was 8.14±0.52 cm, range being6.70 to 9.30 cm.

Table 4: Association of Different Variables for Foot Length with Stature in Study Subjects

Factors	Regression equation
HT versus RFL	HT = 113.83 + 2.102 RFL
HT versus LFL	HT = 114.34 + 2.087 LFL
HT versus AvFL	HT = 125.24 + 1.635 AvFL

Table 5: Statistical Analysis for Foot Breadth in Study Subjects

Variables	RFL (cm)	LFL (cm)	Av. FL (cm)
Mean	8.12	8.04	8.14
SD	0.55	0.54	0.52
Maximum	9.40	9.30	9.30
Minimum	6.70	6.70	6.70
Range	6.70–9.40	6.70–9.30	6.70–9.30

Table 6 shows the regression equation of foot breadth with stature in males and by putting the value of foot breadth in the equation stature can be measured. The average foot index in male was 34.92±3.47. Table 7 shows the correlation between various variables of the male subjects. Statistically significant, positive correlation was seen between all the parameters. In this study, a strong correlation was found between right and left foot length (r=0.774) and right and left foot breadth (r=0.990).

Table 6: Association of Different Variables for Foot Breadth with Stature in Male (N=250)

Factors	Regression equation
HT versus RFB	HT = 116.66 + 5.757 RFB
HT versus LFB	HT = 116.98 + 5.774 LFB
HT versus AvFB	HT = 117.71 + 5.610 AvFB

Table 7: Correlation between Different Variables in Study Subjects

Variables	Correlation coefficient (r)	Correlation
Correlation between HT&RFL	0.745, p=0.000	Strong, positive, statistically significant correlation
Correlation between HT&LFL	0.563, p=0.000	Moderate, positive, statistically significant correlation
Correlation between HT&AvFL	0.640, p=0.000	Moderate, positive, statistically significant correlation
Correlation between HT&RFB	0.605, p=0.000	Moderate, positive, statistically significant correlation
Correlation between HT&LFB	0.596, p=0.000	Moderate, positive, statistically significant correlation
Correlation between HT&AvFB	0.372, p=0.000	Weak, positive, statistically significant correlation

HT, height; RFL, right foot length; LFL, left foot length; RFB, right foot breadth; LFB, left foot breadth; AvFL, average foot length; AvFB, average foot breadth

A significant correlation was found between foot length and stature (r=0.640) and between foot breadth and stature (r=0.372) in study subjects.

DISCUSSION

This study was carried out on a sample of 250 deceased males in mortuary of Department of Forensic Medicine, Mahatma Gandhi Memorial Medical College and M.Y. Hospital, Indore (MP). An attempt was made to correlate foot length with stature and derive regression equations to calculate stature from foot length. On the basis of this foot length and foot breadth, stature was found to be positively correlated and the association was highly significant. The foot length and stature correlation coefficient (r) in males was 0.640. The foot breadth and stature correlation coefficient (r) was 0.372. In this study, the mean stature of male subjects was found to be 163.39±5.26 cm, which was slightly lower than the findings of the other studies [6–8].

The regression equation obtained is 113.83 + 2.102 RFL, 114.34 + 2.087 LFL and 125.24 + 1.635 AvFL in our study. There is variation in mean stature between same sex groups of different studies [9–11]. The stature is determined by several factors which include genetic and environmental factors. This is the reason for wide variation in mean stature amongst individuals of same sex belonging to different endogamous groups.

In this study, the mean foot breadth of male subjects was found to be 8.11±0.73 cm, which was found similar to study of Ozaslan *et al.*[10]. In this study, correlation coefficient in males was found to be (r=0.372) which showed a strong correlation between foot breadth and stature in males which was found to be on higher side in the study of Narde *et al.*[12].

In this study, regression equation for estimation of stature in males from foot length and foot breadth was calculated. The regression equations derived in this study showed a different pattern than earlier studies [13–15]. There are variations in the regression equations in different ethnic groups in India. So regression equations of this study cannot be applied to other population groups.

There is dimensional/proportional relationship between specific body segments and the whole body [4]. Anatomically limbs exhibit consistent ratio relative to the total height of a person and these ratios are linked to the age, sex and race. So the principle of biological correlation of the body parts with each other is applied to estimate stature on an individual.

Foot length was found to be better predictor of stature than foot breadth. In this study, a significant correlation was found between foot dimensions and foot index as well as between stature and foot index. The equations derived in this study can be used to estimate differences related to age, sex and race in forensic and legal sciences.

While anthropometric measurements (stature and built) differ in different sex and ethnic groups due to demographic factors and are strongly influenced by genetic and environmental factors, suggesting the need for different nomograms for each endogamous group. Furthermore, the need for the alternative formulae for the genders is also proved as the rate of skeletal maturity in both sexes vary during the course of development.

These types of studies are of medico legal importance, as the first step in forensic analysis is establishing the identity of the person in question, where stature remains one of the primary characteristics of identification. So the findings of this study will be useful for forensic experts and anthropologists. These studies also help to know the differences between different population groups.

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