ESTIMATION OF HEIGHT FROM FOOT DIMENSIONS

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ABSTRACT

Introduction: A close relationship between stature and dimensions of various body segments is of value in medico-legal investigation as well as in anthropology. Foot length and foot breadth were used by some authors to estimate height in people belonging to different endogamous groups. There is lack of availability of such data in an around the Mahakaushal region.

Objectives: This study was carried out to investigate the relationship between height and foot dimensions among a group of males and females in Mahakaushal region and to derive regression formulae between foot length and height and between foot breadth and height of individual.

Materials and Methods: A cross sectional study was carried out on 342 subjects (170 male and 172 female) in the Mahakaushal region. Stature was measured by a "Standard height measuring instrument". The left foot was taken for the measurement. of foot length and foot breadth with the help of a sliding caliper.

Result: The highest correlation coefficient between foot length and stature was present in males as well as in females. It indicates that foot length provides highest reliability and accuracy in estimating stature of unknown males and females. Prediction of stature was found to be most accurate by linear regression analysis.

Conclusion: Simple regression equation derived from this study can be used to estimate height of an individual of Mahakaushal region.

KEY WORDS: Stature, Foot length, Foot breadth.

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INTRODUCTION

Stature or standing height is one of the most important elements in the identification of an individual. It is the most often used anthropometric dimension and it is a quantitative measure of physique and indicative of physical growth and development of an individual and also useful for calculating body surface area and predicting pulmonary function during childhood. Estimation of individual's stature is an important parameter in forensic examinations. It is defined as "the vertical distance between the highest point of vertex and the heel touching the floor". Examination of footprints

provides important evidence in a crime scene investigation and helps in estimation of stature of a criminal. Analysis of bare footprints is often carried out in developing countries like India where the footprints are frequently recovered at the scene of crime. Ossification and maturation in the foot occur earlier in the long bones and therefore during adolescence age, stature could be more accurately predicted from foot measurements as compared to the measurements of long bones.There have been several studies conducted on different population groups in different parts of world to estimate stature from different parts of body. Several workers have shown a significant correlation between foot measurements and stature in different castes and tribes of different parts of countries.

The present study was carried out to investigate the relationship between foot dimension and stature among group of male and female in Mahakusal region.

MATERIALS AND METHODS

A cross sectional study was carried out on 342 subjects (170 male and 172 female) in Mahakoushal region. The subjects studied were within the age group of 5 to 29 years as stature attains its maximum at around 21 years of age and senility related changes of stature start appearing after 30 years. In the present study, the subjects included, are of different castes and religion and of different socioeconomic status. The subjects having any disease or skeletal deformity have been excluded.

Stature was measured as the vertical distance between the floor and the vertex by a "Standard height measuring instrument". The left foot was taken for the measurement as per the recommendation of the International agreement for paired measurements at Geneva [1912]. The foot length was measured as a direct distance from the most posterior point of back of heel [pternion] to tip of the Hallux or to tip of the second toe (acropodion) by using Venier Caliper. The foot breadth was measured as the direct distance between the most prominent point on medial side (Metatarsal tibalae) and the most prominent on lateral side (Metatarsal fibulae) with the help of Vernier Caliper. The

measurement was taken in centimeter to the nearest millimeter. All the measurements was taken in a well lighted room and in a fixed time between 02:00 p.m. to 4:00 p.m. to avoid diurnal variations and by same person to avoid personal error in methodology. The measurements were taken three times for accuracy.

The various data were recorded carefully up to mm for accuracy and analyzed thereafter. Various data of study were recorded into the computers and after its proper checking for error, coding & decoding was compiled and analyzed using the software SPSS 20 for windows. The critical levels of significance of the results were considered at 0.05 levels i.e. $P < 0.05$ was considered significant.

Fig. 1: Measurement of Foot length.

Fig. 2: Measurement of foot breadth.

RESULTS

The mean age of males was 17.27 years with standard deviation (SD) of 5.424 whereas the mean age of females was 15.85 years with standard deviation (SD) of 6.069.

Table 1: Distribution of subjects according to age and gender.

Age in years	Sex		Pooled
	Male	Female	
5-9	22 (12.9%)	42 (24.4%)	64 (18.7%)
10-14	24 (14.1%)	18(10.5%)	42 (12.3%)
15-19	40 (23.5%)	51 (29.7%)	91 (26.6%)
20-29	84 (49.4%)	61 (35.5%)	145 (42.4%)
Total	170 (100%)	172 (100%)	342(100%)
Mean ±SD	17.27±5.424	15.85±6.069	16.56±5.793

Table 2: Foot dimension and Stature in different sex.

Variables	Male		Female		Value of t	Significant
	Mean	S.D.	Mean	S.D.		
Stature in cm	159.21	18.64	145.22	18.02	7.051	p<0.000
Foot length in cm	24.62	2.75	22.24	2.46	8.44	p<0.000
Foot breadth in cm	9.92	1.07	8.99	0.9	8.69	p<0.000

We have seen that mean height was found to be 159.21±18.64cm in male subjects and 145.22±18.02cm in female subjects. The mean foot length was found to be 24.62±2.75cm in male subjects and 22.24±2.46cm in female subjects. The mean foot breadth was found to be 9.92±1.07cm in male subjects and 8.99±0.90 cm in female subjects. The differential trends as assessed by mean of t-test reveal highly significant sex differences (p<0.000) for Stature, for foot length and for foot breadth.

Table 3: Stature Vs Foot length.

	Male	Female	Combined
Correlation coefficient (r) (Height and Foot length)	0.958	0.936	0.953
Regression coefficient (b) (Height and Foot length)	6.52	6.82	6.53
Value of constant (a) (Height and Foot length)	-1.3	-6.45	0.78

Table 4: Stature Vs Foot breadth.

	Male	Female	Combined
Correlation coefficient (r) (Height and foot breadth)	0.845	0.87	0.874
Regression coefficient (b) (Height and foot breadth)	14.75	17.24	15.66
Value of constant (a) (Height and foot breadth)	12.82	-9.76	4.08

The following Regression formulae were derived.

Regression formula from foot length for Males: Stature (y) =6.52 foot length-1.30

Regression formula from foot length for Females: Stature (y) =6.82 foot length-6.45

Regression formula from foot length for both Genders: Stature (y) =6.52 foot length+ 0.78

Regression formula from foot breath for Males: Stature (y) =14.75 foot breath+12.82

Regression formula from foot breadth for Females: Stature (y) =17.24 foot breath -9.76

Regression formula from foot breadth for both Genders: Stature (y) =15.66 foot breath + 4.08

DISCUSSION

Charnalia (1961) conducted a study on 541 males belonging to 8 different castes and tribes of Pondicherry. Found Stature had a higher correlation with foot length [0.46] than with foot breadth (0.33) [1].

Rutishuser(1968) found significant correlation between foot length and height. The author also derived regression equations to calculate height from foot length [2].

Qamra et al (1980) computed linear regression equation for estimating height from foot length and foot breadth. They found a good correlation of height with foot length [male; r= 0.69 and female; r=0.70] and foot breadth [male; r=0.42 and female r=o.47] [3].

Giles and Vallandigham(1991) studied the correlation between foot length and height using the database of U.S. army personnel. They found a correlation of 0.678 for males and 0.693 for females for foot length and height [4].

Jasuja OP et al (1991) measured stature, foot length, foot breadth, and shoe length and shoe breadth. They derived multiplication factors from

these measurements to estimate height. They also revised these multiplication factors to reduce error [5].

Surinder Nath and Divya Chang (2001) formulated regression formula for estimation of stature from hand length and foot length among data from 256 adult male Jat Sikhs from different village of Patiala district of Punjab. They measured their stature, foot length, foot breadth, shoe length and shoe breadth and derived multiplication factors from these measurements to calculate stature from the foot and shoe measurements. They also revised these multiplication factors to reduce error [6].

Ozaslan et al. (2003) correlating the various lengths of the lower extremity and stature. They found a good correlation between lower limb measurements and stature [7].

Patel et al (2007) carried out a study in Gujarat region. Found the correlation coefficient between height and foot length as +0.65 in males and +0.80 in females which was most significant also derived regression equations to calculate the height from foot length (H=75.45+3.64FL for males and H=75.41+3.43 for females) [8].

Arun Kumar Agnihotri et al. (2007) developed a relationship between foot length and stature using linear and curvilinear regression models. General multiple linear regression model was highly significant (P<0.001) and validated with highest values for the coefficients of determination R (2) =0.769 and multiple correlation coefficient r=0.877 [9].

Krishan K (2008) conducted a study to reconstruct stature in a sample of footprints and foot outlines obtained from 1040 Gujjars of North India. The study showed significant positive correlation existing between stature and various measurements of footprints and foot outline [10].

Jaydip Sen et al. (2008) conducted a study to estimate sex from foot length, foot breadth, and foot index among 350 living adult Rajbanshi (175 men and 175 women) individuals (age range: 18–50 years). They concluded that foot dimensions show significant sex differences and higher correlation between foot length and stature [correlation coefficient r=0.623 for males and 0.682 for females] than that between foot breadth and stature [correlation coefficient r=0.523 for males and 0.387 for females) [11].

Kanchan et al. (2008) studied the relationship between stature and foot dimensions among 200 subjects (100 males and 100 Female) Gujjars, a North Indian endogamous group. They derived multiplication factor and regression equations from foot dimension to estimate stature [12].

Gulash et al. (2008) conducted a study to estimate stature and gender using foot measurements on 249 adults [113 females and 136 males] aged between 18 -44 year born in Turkey. They found highest correlation to be present between foot length and stature than between other foot measurements and stature [13].

Bhavana and Nath (2009) estimated stature on the basis of measurements of lower limb in 503 male Shia Muslims in. Analysis of their study revealed that tibial length amongst males exhibited the highest value of correlation with stature (r=0.765), while the foot breadth exhibited the lowest correlation with stature [14].

The present study shows that sex differences are highly significant for all measurements (p<0.000). The male subjects exhibit greater dimensions than the female subjects, for foot and stature. The significant differences in stature and foot measurements in males and females can be attributed to fact that fusion of epiphyses of bones occurs earlier in girls and later in boys.

Stature, foot length and foot breadth are positively and significantly correlated with each other (p<0.01). The higher correlation coefficient between stature and foot length over that of stature and foot breadth points to fact that foot length rather than foot breadth, is more accurate in estimating stature. But this does not rule out the importance of foot breadth in stature estimation in medico legal cases as there may be situations when only a part of foot may be available for analysis, where only foot breadth can be measured.

The study was conducted on a population group with individuals residing/studying in mahakaushal region. The regression equation derived in study can be use accurately and

reliably for estimation of stature in a diverse population group.

CONCLUSION

Simple regression equation derived from this study can be used to estimate height of individuals of Mahakaushal region. This fact will definitely be useful in medicolegal investigations and in anthropological and archeological studies where total height of an individual can be calculated if foot dimension is known.

Conflicts of Interests: None

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