An Anthropometric Study of Stature Estimation from Foot Morphometry in North Indian Population

Bhamini Sharma[1], Reena Singla[2], Vishal Verma[3]

[1]M.Sc. Student, Department of Anatomy, [2]Professor, Department of Anatomy,
[3]Asstt. Prof. Department of Anatomy, MMIMSR, MMDU, Mullana-Ambala

Abstract

Background and Objectives: The aim of present study is to find the correlation of foot morphometry with stature and to derive the regression equation for stature estimation among two endogamous (baniya and jats) groups of North India.

Material and Method: The present study was carried out at Department of Anatomy, MMIMSR Mullana–Ambala, on 400 subjects(100 males,100 females of each group) belonging to known endogamous group (baniya and jats) of Haryana, age group ranged between 21-35 years. Height and foot length,foot breadth was measured. Foot index was calculated. Statistical analysis including mean, standard deviation for stature and foot morphometry of both sides were calculated separately for both sexes. Pearson's correlation coefficient was calculated to find correlation between stature and different foot morphometry .To estimate stature from foot morphometry linear regression analysis was done.

Results: The mean and standard deviation for height in males was 173.68 ± 7.336 and in females was 160.73 ± 10.049 with highly significant p value. The mean foot length,foot breadth of males was higher than females with statistically significant p value. In males, the foot length and foot breadth of both sides have a highly significant correlation with height. In females the correlation of height was highly significant with foot length, foot breadth and foot index among both the groups.

Conclusion: A significant correlation coefficient was observed between height and foot length in males. In females, a significant correlation was observed between height and foot length and foot breadth. If either of the measurement is known(height or foot length/foot breadth), the other can be calculated. This would be useful for Anthropologists and Forensic medicine experts.

Keywords: *Foot length, Foot breadth, Foot index, jats, baniya, correlation.*

Introduction

Anthropometry is a series of systematic measuring techniques that express quantitative dimensions of human body and skeleton.[1] Forensic investigations use an anthropometric approach in the identification of victims.[2] Over the years,the anthropometric measurements of various anatomical structure for prediction and estimation of stature has become very useful,especially when the skeletal remains are often observed to be incomplete or extensively dismembered.[3] Stature estimation has a very important role to play in forensic anthropometry for personal identification. Specifically, since each individual has different variations of body profile, estimating someones height can have an important role in an investigation.[4]The stature of an individual is an inherent characteristic which varies with race and it is determined by genetic constitution

Corresponding Author:
Dr. Reena Singla
Professor, Department of Anatomy, MMIMSR,
MMDU, Mullana-Ambala
e-mail: singla.reena@ymail.com
Mobile No.: 9896212241

of a person, geographical location, environment and the climatic conditions. With increasing frequency of mass disasters, it is essential to find out correlations between stature, age, and sex of an individual with variable information collected from different systems, organs or its parts which is of immense importance.[5] Stature plays a key role in establishing the identity from unknown, decomposed and fragmented remains in medico legal cases.[6] Human stature is an anatomical complex of linear dimensions,including skull,vertebral column,pelvis and lower extremities,so that it is assumed that significant association exist between the total stature and these individual body parts.[7,8,9]. Stature of a person is proportional to dimensions of various body parts . It is established that dimensions of lower extremity show higher association with stature than upper extremity.[6]

Height estimation by measurement of various long bones has been attempted by several workers. Each worker has derived own formula to estimate height from long bones. In 1968, Rutishauser for the first time showed that the reliability of prediction of height from foot length was as high as that from long bones. Ossification and maturation in the foot occurs earlier than the long bones and therefore,during adolescence age,height could be more accurately predicted from foot measurement as compared to that of long bones.[10]

Like other parts of body such as head,trunk,lengths of upper and lower limbs,the foot size also displays a definite biological correlation with stature on the basis of this relationship it is possible to predict the stature from foot and its segments.[11] Various studies have reported a statistically significant positive association of stature with foot measurements.[7,12] Some studies suggest the use of stature –foot index, multiplication factor method[13,14,15] and regression equation method[11] to estimate stature from foot dimensions. The aim of present study is to find the correlation of foot morphometry with stature and to derive the regression equation for stature estimation among two endogamous (baniya and jat) groups.

Material and Method

The present study was carried out at Department of Anatomy, MMIMSR Mullana –Ambala, on 400 subjects(100 males,100 females of each group) belonging to known endogamous group (baniya and jaat) of Haryana, age group ranged between 21-35 years .Prior written consent for the study was taken from all the subjects both in English and in vernacular. Cases with foot anomalies, trauma, inflammations and surgery was excluded for the investigation.

Equipments used: Osteometric board, Flexible metallic measuring tape.

Height was measured by making the subject stand erect and barefooted on a flat floor and the vertical distance between the point vertex, (highest point on the head), when the head is held in the Frankfurt's horizontal plane (which is obtained by joining the infra orbital margin to the upper margin of external acoustic meatus) and the heel touching the floor was measured in cms.

Foot measurements were taken with the help of osteometric board:

- **Osteometric board:** Osteometric board is an anthropometric instrument that consists of a flat board with two ends, one of which is movable and travels along a routed track. This is a preferred instrument for measuring long bones. The object to be measured is placed between the two end pieces and the movable end brought up to the object, where the measurement scale can be read.
- **Foot length:** Foot length was taken as a straight distance between the most posteriorly projecting points of heel (pternion) to the most anterior projecting point (Acropodion) of the first or the second toe whichever will be bigger when the foot is fully stretched.
- **Foot breadth:** Foot breadth was measured as a straight distance from metatarsaletibiale (the most medially placed point on the head of first metatarsal) and metatarsalefibulare (the most laterally placed point on the head of the fifth metatarsal) when the foot will be fully stretched.
- Foot index = foot breadth/foot length x 100

Statistical analysis: Data was analyzed using Statistical Package for Social Sciences (SPSS, version 20).Descriptive statistics including mean, standard deviation, minimum and maximum value for stature and foot morphometry of both sides were calculated separately for both sexes. Pearson's correlation coefficient was calculated to find correlation between stature and different foot morphometry. To estimate stature linear regression analysis was applied.

Results

The mean and standard deviation for height in males was 173.68 ± 7.336 and in females was 160.73 ± 10.049 with highly significant p value. The mean foot length, foot breadth of males was higher than females with statistically significant p value.(Table 1). In Baniya males, the foot length of both sides have a highly significant correlation with height at 0.01 level(2 tailed) and foot breadth of both sides is significantly correlated with height at 0.05 level(2 tailed). In Jat males, Right foot length and right foot breadth shows a correlation which is significant at 0.05 level (2 tailed) and left foot length and height are correlated and this correlation is highly significant at 0.01 level (2 tailed). The correlation of foot length, foot breadth and foot index in females of both the groups was highly significant at 0.01 level (2 tailed) as compared to the male group.(Table 2) The linear regression equations were applied on the parameters, which were highly correlated with height. In males, foot length (right and left) and in females, foot length(right) and foot breadth(left side). From these parameters, certain equations to estimate stature (dependent variable) from foot morphometry (Independent variable) are derived as follows: Linear regression equation to estimate height for various parameters studied in male and female group:

In Jats:

Height = 126.597 + 1.979 (Left foot length)

In baniya :

Height = 109.262 + 2.457 (Right foot length)

Linear regression equation to estimate height for various parameters studied in females:

In Jats:

Height = 90.831 + 2.920 (Right Foot Length)

Height = 88.309 + 1.744 (Right Foot Length) + 3.318(Left Foot Breadth)

In baniya :

Height = 189.636 – 3.616 (Left Foot Breadth)

Height = 133.758 + 2.453 (Right Foot Length) – 3.520 (Left Foot Breadth)

Table 1: Descriptive statistics of Age, Height and Foot morphometry among study population

Parameters		Males (Mean ± SD) N=200	Females (Mean ± SD) N=200	p value
Age		24.80 ± 3.759	24.91 ± 3.307	0.7562
Height		173.68 ± 7.336	160.73 ± 10.049	<0.001
Foot Breadth	Right	9.59 ± 1.136	8.60 ± 0.913	<0.001
	Left	9.96 ± 1.251	8.86 ± 0.986	<0.001
Foot Length	Right	26.26± 1.600	23.48 ± 1.846	<0.001
	Left	26.60 ± 1.609	23.79 ± 1.868	<0.001

Table 2: Correlation between stature and foot morphometry among study groups

Study Groups	Sex	Height (Mean)	Correlation				Foot Index	
			Right Foot Length	Right Foot Breadth	Left Foot Length	Left Foot Breadth	Right Foot	Left Foot
Baniya	Male	170.626	0.000**	0.027*	0.000**	0.05*	0.337	0.49
	Female	158.196	0.008**	0.005**	0.028*	0.001**	0.000**	0.000**
Jat	Male	176.73	0.023*	0.035*	0.003**	0.853	0.571	0.355
	Female	162.791	0.000**	0.000**	0.000**	0.000**	0.044*	0.023*

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Discussion

The present study focused on foot morphometry and its correlation with stature among two endogamous groups (Baniya, jats) of North India. It was seen that a significant correlation was seen between height and foot length in male study group. Among females, height is showing significant correlation with foot breadth, foot length and foot index (in jats and baniya females). (Table 2) Various previous studies conducted to find correlation between stature and foot morphometry agrees with our study. They concluded that there is significant correlation between height and various foot parameters as shown in Table 3.

Table 3: Comparison of correlation between stature and foot morphometry of present study with previous studies

Study	Sample size	Males	Females	Parameters
Present study	400	200	200	Height and foot length,foot breadth and foot index
Patel SM et al[16] (2007)	502	278	224	Height and foot length
Mansur DI et al.[17] (2012)	440	258	182	Height and foot length
Shailesh M Patel et al[18] (2011)	285	149	136	Height, foot length and foot breadth
Mohantry BB et al[19] (2012)	300	206	94	Height and foot length
Shankar GS et al[20] (2018)	234	98	136	Height and foot length

Stature estimation is considered as one of the important parameters in identification of a person. various body parts shows biological correlation with stature. Therefore,many workers have utilized this fact to use body parts or skeletal remains to estimate stature. A study by Qamra et al [21],measured height,foot length and foot breadth of 1015 adults (519 males and 496 females). They developed method for estimating height from foot morphometry. Sen et al [22] studied the foot measurements and stature of Rajbanshis of West Bengal (150 males,150 females) and derive various formulas to evaluate height from foot morphometry. Kanchan et al[23] studied the relationship between stature and foot dimensions among Gujjars,a north indian endogamous group . They measured height, foot length and foot breadth on 100 males and 100 females and derive multiplication factors and regression equations from foot dimensions to estimate stature. Dhaneria et al,[24] concluded that foot length and foot breadth showed positive correlation with stature .out of both these parameters foot length is a better predictor of stature they also derive linear regression equation for estimation of stature from foot length and foot breadth.

Conclusion

The present study has established a strong correlation between height,foot length and foot breadth among study groups. Regression equation have also been established. In males,the correlation between height and foot length was more than foot breadth. In females,both foot breadth and foot length has significant correlation with height. In baniya females in addition to foot length and foot breadth,a significant correlation was seen between height and foot index. To conclude,foot length can be considered as a better predictor of stature in males than in females. Among comparison between endogamous groups in baniya females besides foot length and foot breadth, foot index is also a good predictor of stature. If either of the measurement (foot length,foot breadth,stature)is known the other can be calculated. However, these equations are population specific and cannot be applied to other population. Therefore,population specific studies are suggested that may be useful in examining dismembered human remains in medicolegal cases.

Conflict of Interest: Nil

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Ethical Clearance: Ethical clearance and approval was obtained from the institutional Ethics Committee

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