Estimation of Height from Foot Measurement in Kalaburagi District

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Abstract

Estimation of height of a person plays an important role in identification of a person which is necessary in criminal cases and as well as in mass disasters where only a portion or a part of body may be seen. The present study was carried out on the measurement of foot length and body height of 342 students (170males and 172 females) of 05 to 30 years of age. Anthropometric measurements were taken by using anthropometric instruments in centimeter to the nearest millimeter. All the measurements were taken in a well lighted room. Obtained data was analysed for correlation coefficient and to derive a regression formula between

foot length and height of an individual. A medium correlation of height was observed with foot length and it was statistically significant. The present study would be useful for anthropologists and forensic experts

Key words: *Co-relation coefficient, Forensic Anthropology, Foot Length, Regression Equation, Stature*

Introduction

The science of measuring the body parts constitutes Bertillon's system or anthropometry.

Historical aspect of anthropometry as a means of establishing human identity is pretty interesting. It is also viewed as a traditional and basic tool of biological anthropology[1], but it has a long tradition of use in forensic sciences. Relationship that exists between different parts of the body and height has been of great interest to anthropologists, artists, scientists, anatomists, and medico-legalists for a long time. Height estimation by measurement of various long bones has been attempted by several workers with variable degree of success[2,3,4]. The significant body segments for estimation of stature are length of foot, hand, hand with forearm, arm, upper

extremity and lower extremity bones, head length, head circumference, distance between sternal notch and pubic symphysis, crown to rump and rump to heel ratio etc individually or in various combinations[5,6,7]. 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 from long bones[8]. There are a lot of variations in estimating stature from limb measurements among people of different region and race. Hence there is a need to conduct more studies among people of different regions and group so that stature estimation becomes more reliable and identification of an individual is easily established. The aim of our study is to help in the identification of victims of mass deaths due to natural calamities or manmade disasters from fragmentary and dismembered human remains, identification of criminals from foot print & to find if there is any sex and racial differences of height when compared to foot length. The study also aims to find out any correlation of height with foot length among male and female population of kalaburagi district of

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Karnataka state & to predict and estimate height from foot length by deriving a regression equation.

Materials and Methods

This observational cross sectional study using convenient sample technique was done over a period of 1 year from march 2019 to February 2020. The present study was carried out in the department of forensic medicine and toxicology at KBNIMS Kalaburagi. A total of 342 subjects were included in the study, out of which 170 males and 172 females within age group of 05 to 30 years. The subjects included in study were healthy individuals free from any apparent skeletal deformity. The left foot was taken for the measurement as per the recommendation of the International agreement for paired measurements at Geneva. Besides the above measurements, stature of each subject was also recorded. All measurements were taken in well lighted room. The measurements were taken by using standard anthropometric instruments in centimeters to the nearest millimeter in following manner.

Anthropometric Measurement

Foot length: It is the distance from the most prominent part of the heel backward to the most distal part of the longest toe (2nd or 1st).

Instrument: Vernier Calliper.

Technique: The measurement was made on standing subject. The calliper was horizontally placed along the medial boarder of the foot. The fixed part of the outer jaw of the calliper was applied to the pternion and the mobile part of the outer was approximated to the acropodian and measurement were taken. In the same way measurement of the other side were taken.

Stature: It is the vertical distance between the point vertex and the heel touching the floor (ground surface).

Technique: The subject was made to stand in erect posture against the wall with the feet axis parallel or slightly divergent and the head balance on neck and the measurement was taken. The data was collected, analysed and subjected to statistical analysis using statistical package for social sciences (SPSS) to know the correlation of the stature with the length of feet and simple linear regression formulae were derived for various combinations. The reliability of estimation of stature from the lengths of feet was determined with the help of standard error of estimation (SEE).

The exclusion criteria were:

1. Major ailments in the past affecting foot.

2. Past history of injury, fracture, surgery of foot.

3. Congenital or acquired deformity of foot, or spines.

4. Past histories of generalized disease affecting height like rickets, osteomyelitis, gigantism, dwarfism, achondroplasia, cretinism etc.

Results and Analysis

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 to 9	22(12.9%)	42(24.4%)	64(18.7%)
10 to 14	24(14.1%)	18(10.5%)	42(12.3%)
15 to 19	40(23.5%)	51(29.7%)	91(26.6%)
20 to 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	SD	Mean	SD		
Stature in cm	159.21	18.64	145.22	18.02	7.05	P<0.00
Foot length in cm	24.62	2.75	22.24	2.46	8.44	P<0.00
Foot breath in cm	9.92	1.07	8.99	0.9	8.69	P<0.00

Table 3: Stature Vs Foot length.

	Male	Female	Combined
Correlation coefficient (r) (Height and Foot length)	0.95	0.93	0.95
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)	0.84	0.87	0.87
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

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. 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 breadth 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 breadth + 4.08

Discussion

Patel et al (2007)10 carried a study in Gujarat region and found the correlation coefficient between height and foot length as +0.65 in males and +0.80 in females; also derived regression equations to calculate the height from foot length as: H= 75.45 + 3.64FL for males and H=75.41 + 3.43 for females (H= Height, FL= Foot Length). Jaydip Sen et al (2008)11 conducted a study to estimate sex from foot length, foot breadth, and foot index among 350 living adult (age range: 18–50 years) Rajbanshi individuals (175 men and 175 women). 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]. Mohanty & Agrawal12 studied a population of 300 students (M=206, F=94) aged 18—25 years of Odisha and developed a regression equation that could calculate the height of an individual from his

foot length. They found that as height increases foot length of both male and female also increases. Krishnan (2008)13 examined the relationship of stature to foot

size of 1040 adult male Gujjars of North India (age 18 to 30 years) and found that the highest correlation coefficient were shown by the toe length measurements (0.79 – 0.86). Agnihotri et al (2007)14 developed a relationship between the foot length and stature using linear and curvilinear regression analysis on a study group comprising of 250 medical students (125 males and 125 females) aged 18–30 years. It was concluded that general multiple linear regression model was highly significant (p<0.01) and validated with highest value for the coefficient of determination R^2 = 0.769 and multiple correlation coefficient r = 0.877.

Conclusion

Simple regression equation derived from this study can be used to estimate height of individuals. 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.

Conflict of Interest: Nil

Source of Funding : Self

Ethical Clearance : Taken from KBNIMS ethical committee

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