Stature estimation from forearm lengths in North Karnataka population; India

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Abstract
Stature is an important parameter of personal identification of an individual there are many studies conducted along with others parameters such as age, sex, race, etc. The present study is an attempt to examine the relationship between the stature and right forearm length of 100 males and 100 females of north Karnataka, population in age ranging from 21 to 35 years. Linear and multiple regression equations formula for stature estimation were calculated. The co-relation co-efficient between stature and both right and left forearm length were found to be positive and statistically significant (P<0.01). The highest co-relation co-efficient is +0.65 for left forearm length. The regression formula was checked for their accuracy, applicability and reliability.

Keywords: Human anatomy, Anthropology, Stature, North Karnataka.

Introduction
Anthropometry is a series of systemized measuring techniques that expresses quantitatively the dimensions of human body and skeleton. Anthropometry is often viewed as a traditional and perhaps the basic tool of biological anthropology, but it has a long tradition of use in forensic sciences. The significance and importance of craniometry, somatometry, cephalometry and osteometry in the identification of human remain have been described and a new term "Forensic Anthropometry" is coined.[1] Forensic Anthropology, an applied discipline, is a branch of physical anthropology which interacts with other disciplines pertaining to the understanding of crime and its investigations. Forensic anthropology becomes important nowadays as the scientific techniques for foul play have been sophisticated.

Examination of skeletal remains and mutilated body parts recovered from crime scene has often been used by the forensic anthropologists to extract relevant personal information about the victim. There is increase in the number of catastrophic events causing mass death from natural and manmade errors. Such disasters like flooding, tsunamis, earthquakes, plain crashes, train crashes, terrorist attacks usually requires the identification of victims from fragmentary and dismembered human remains.

In such situations, the stature prediction occupies relatively a central position in the identification of an individual necessitated by the medical jurisprudence or by the medico-legal experts. The foundation from which anthropology has developed includes the 'Big Fours' - Age, Sex, Race and Stature which helps in personal identification.[2]

Identification is an individual's birth right.[3] Stature is one of the basic indicator of the biological profile that can aid in the identification of an individual. It helps distinguish between multiple individuals who have the same ancestry, sex and age, and thus provides a circumstantial or presumptive identification of an individual. Based on the correlation, attempts have been made to establish the stature from the dimensions of almost all the body parts bones.[4]

There are two major methods used to estimate stature; Mathematical method and the Anatomical method. The Mathematical method takes advantage of the higher linear correlation between long bones and stature. With a long bone as the dependent or independent variable, one can utilize regression equation that reflects the relationship between an individual's stature and the chosen long bone. The Anatomical method, more commonly referred as "Fully's Method", reconstructs stature by summing the measurements of the skeletal elements that contribute to the height and adding a correction factor for the soft tissue.[5,6]

In the present scenario, personal identification of a living person has become a common problem and such problem has risen in the court of law in relation to various crimes such as rape, murder, child trafficking etc.

Thus when the complete skeleton is not available for identification of an individual, the forensic experts must use mathematical method of stature estimation instead of anatomical method. Mathematical method has the obvious advantage that it is workable even if a single long bone or its fragments are available for stature estimation.

Estimation of stature especially from bones is a tedious and time consuming process which involves cleaning and preparation of bones. Due to this reason forensic anthropologist are using percutaneous measurements instead of direct measurements of the bone.[7] For stature estimation researches different nutrition types and physical activities may cause variations in populations. Many studies are successfully performed on this topic despite a wide range of ethnics and races through the populations.

There have been many researches on stature estimation from various body segments. But there are only a handful of studies in this region of north Karnataka. Again very few studies have concentrated on estimation of stature from forearm length. Thus the present study aims at estimating

stature from forearm lengths that will help in forensic medico-legal work.

Objectives

1. To derive linear regression formulae to estimate stature from these dimensions obtained.
2. To evolve linear regression equation for males and females separately.

Statistical Method Adopted

All the measurements were analysed by using SPSS software[8]. The results were presented separately for males and females. Initially the data was summarised into Minimum value, Maximum value, Mean, Standard Deviation and Range for all the parameters. To study the relationship of forearm lengths with the stature, the Pearson Correlation Coefficient was estimated and the significance was tested through Z- test. Linear Regression Equations were derived to estimate stature of unknown from forearm length.

Correlation Coefficient

The relationship or association between two variables is called correlation. The extent or degree of relationship between two set of figures is measured in terms of a parameter called Correlation Coefficient. It is mathematically estimated by a formula and is denoted as Pearson's Correlation 'r'.

If r = 0: there is no correlation	If r = -1: there is perfect negative correlation
If r = +1: there is perfect positive correlation	If r = 0-0.1: trivial correlation
If r = 0.1-0.3: small correlation	If r = 0.3-0.5: moderate correlation
If r = 0.5-0.7: large correlation	If r = 0.7-0.9: very large correlation
If r = 0.9-1 : near perfect correlation	

Regression

The word regression means prediction. It is a method to estimate or predict the value of unknown variable from the value of known variable. This is possible only when the two variables are linearly correlated. The variable to be estimated is called dependant variable and the variable which is known is called independent variable. The mathematical equation from which dependant variable can be calculated is called regression equation.

Materials and Method

Source of Data: 200 healthy adult population, 100 males and 100 females residing in Bijapur district are selected from among those volunteering for the study, only after obtaining informed consent.

Method of Collection of Data: Stature is measured using anthropometry. Forearm length is measured using first segment of anthropometric rod. All the measurements are taken before noon to avoid diurnal variation as the stature is maximum in morning and decreases by 1.5-2.0 cm by the end of the day

Inclusion Criteria: Male and female age range between 21 to 35 years and all being healthy are considered in the present study.

Exclusion Criteria:

1. Subjects with skeletal abnormalities, deformities and endocranial disorders.
2. Persons with amputated fingers will be excluded from the study.

Measurements

Stature: It is measured as vertical distance from the vertex to the floor as in Fig. 1. Measurement is taken by making the subject stand erect in anatomical position on a horizontal resisting plane with bare footed. Shoulder blades and buttocks are touching the wall. Anthropometer is placed in straight vertical position in front of the subject with head oriented in eye-ear-eye Plane (Frankfurt Plane). The movable rod of the Anthropometry is brought in contact with vertex in the mid saggital plane.

Fig. 1

Forearm Length: Forearm is placed on flat, hard and horizontal surface with extended and adducted fingers so that the forearm is directly in longitudinal axis with the middle finger. Distance from head of radius to tip of styloid process of radius is taken as forearm length with the first segment of anthropometer as in Fig. 2.

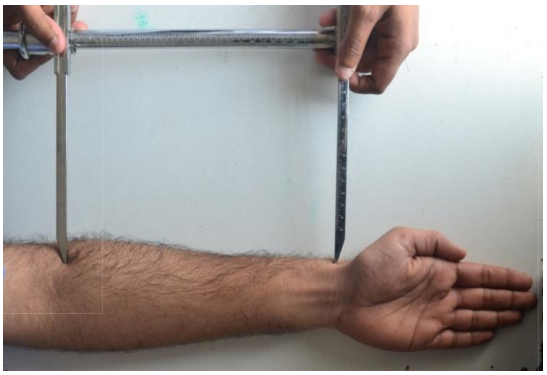

Fig. 2

Results

Table 1: Minimum, maximum, mean, standard deviation (SD) and range of height measurements included in present study

	Min. (in cm)	Max. (in cm)	Mean (in cm)	SD	Range (in cm)
Females	145	169	154.34	5.49	24
Males	160	184	171.73	5.01	24

Among female subjects, the mean height is 154.34±5.49 cm minimum height is 145 cm and maximum is 169 cm with range being 24 cm.

Among male subjects, the mean height is 171.73±5.01 cm minimum height is 160 cm and maximum is 184 cm with range being 24 cm.

Table 2: Minimum, maximum, mean, standard deviation (SD) and range of right forearm length measurements included in our study

	Min.(cms)	Max. (cms)	Mean(cms)	SD	Range	r value	p value
Females	20.1	26.7	22.61	1.35	6.6	0.5980	0.001
Males	22.6	28.8	26.2	1.20	6.2	0.5139	0.001

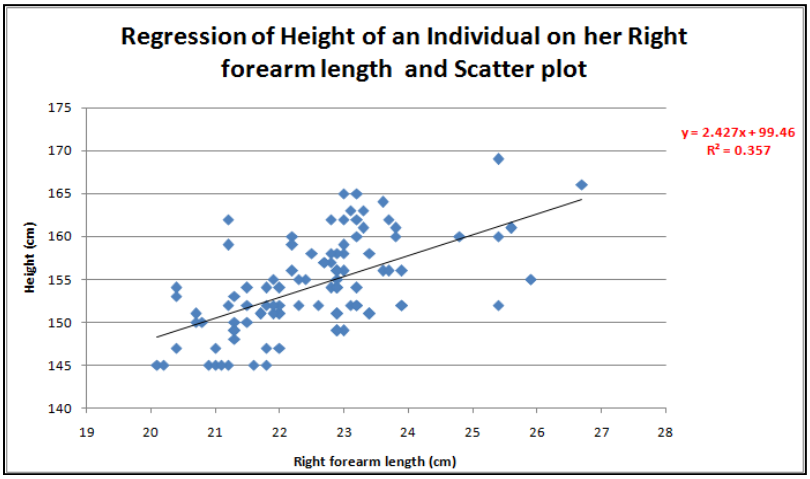

Fig. 3: Regression of height on right forearm length in females included in our study group and scatter plot

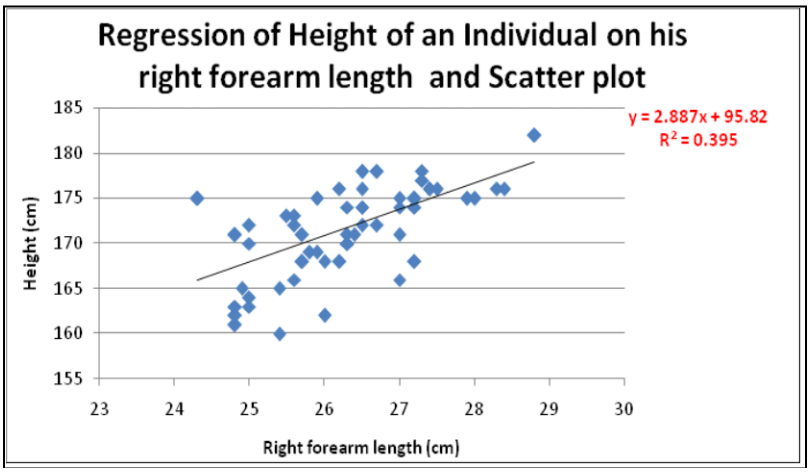

Fig. 4: Regression of height on right forearm length in males included in our study group and scatter plot

In female subjects mean right forearm length is 22.61±1.35 cms, minimum is 20.1 cms and maximum is 26.7 cms with range being 6.6 cms. Correlation coefficient (r) of right forearm length with stature of female subjects is 0.5980. Thus stature is strongly correlated with right forearm length of females included in our study group.

Multiplication factor to calculate stature from right forearm length is 2.427 and constant being 99.46. The regression equation is formulated as;

Stature of females in cms = 2.427 x RFL + 99.46.

In males, the mean right forearm length is 26.2 ± 1.20 cms, minimum is 22.6 cms and maximum is 28.8 cms with range being 6.2 cms. Correlation coefficient (r) of right forearm length with stature in male subjects is 0.5139. Thus stature is strongly correlated with right forearm length of males included in our study group.

Multiplication factor to calculate stature from right forearm length is 2.887 and constant is 95.82. The regression equation is formulated as;

Stature of males in cms = 2.887 x RFL + 95.82.

Table 3: Minimum, maximum, mean, standard deviation (SD) and range of left forearm length measurements included in our study

	Min.(cms)	Max. (cms)	Mean(cms)	SD	Range	r value	p value
Females	20.0	26.3	22.12	1.36	6.3	0.6150	0.001
Males	22.1	28.8	25.94	1.27	6.7	0.5009	0.001

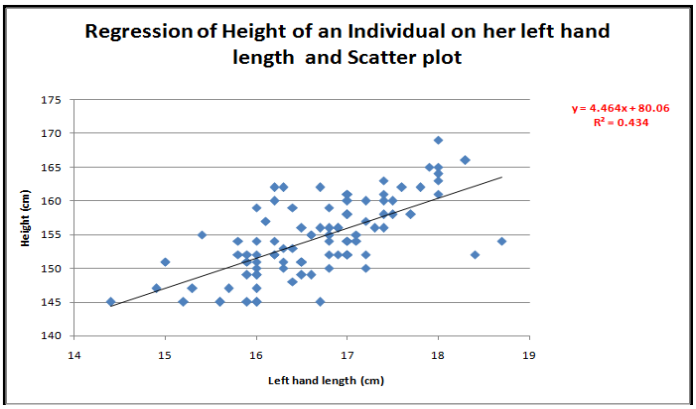

Fig. 5: Regression of height on left hand length in females included in our study group and scatter plot

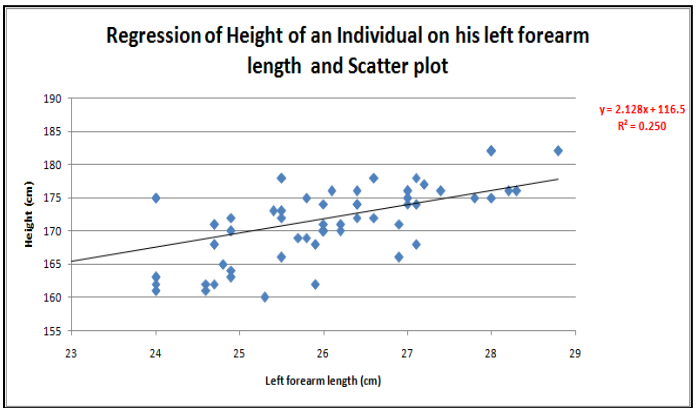

Fig. 6: Regression of height on left forearm length in males included in our study group and scatter plot

In females mean left forearm length is 22.12±1.36 cms, minimum is 26.7 cms and maximum is 26.3 cms with range being 6.3 cms. Correlation coefficient (r) of left forearm length with stature of female subjects is 0.6150. Thus stature is strongly correlated with left forearm length of females included in our study group.

Multiplication factor to calculate stature from left forearm length is 2.632 and constant is 95.08. The regression equation is formulated as;

Stature of females in cms = 2.632 x LFL + 95.08.

In males mean left forearm length is 25.94±1.27 cms, minimum is 22.1 cms and maximum is 28.8 cms with range being 6.7 cms. Correlation coefficient (r) of left forearm length with stature of male subjects is 0.5009. Thus stature is strongly correlated with left forearm length of males included in our study group.

Multiplication factor to calculate stature from left forearm length is 2.128 and constant being 116.5. The regression equation is formulated as;

Stature of males in cms = 2.128 x LFL + 116.5.

Discussion

In the first study of its kind, Rollet assessed the correlation between stature and long bone length. He measured the lengths of the radius, ulna, humerus, fibula, tibia and femur of adult French cadavers and published a report with the methods of measurement, the individual measurements, and tables of stature estimations.[9,10]

Pearson (1899) used Rollet's data to create regression formulae for estimating stature. He used only long bone lengths of the right side. He found through analysis of Rollet's data that age shrinkage was not a significant factor for stature estimation. Mildred Trotter and Goldine Gleser, however, later provided evidence that age shrinkage is a significant consideration when estimating stature. Pearson contributed greatly to the advancement of stature estimation.[11]

In Maharashtrian population, Anjali P et al observed mean right forearm length as 26.92±1.32 cms in males and 21.75±0.92 cms in females. Right forearm length showed positive correlation with stature in both the sexes with correlation coefficient of 0.65 in males and 0.68 in females. Regression equations to calculate stature were Stature = 2.92 x RFL + 93.45 in males and Stature = 2.37 x RFL + 113.89 in females.[12]

In a similar study, Anupam KB et al calculated mean right forearm length as 27.81±2.02 cms in males 24.80±1.92 cms in females. Correlation of stature with right forearm length was found as r = 0.61 in males and r = 0.64 in females. Regression equations Stature = 1.63 x RFL + 92.51 in males and Stature = 3.16 x RFL + 99.45 in females.[13]

In present study right forearm length is measured as 26.2±1.20 cms in males and 22.61±1.35 cms in females. Correlation of stature with right forearm length is deduced as r = 0.513 in males and r = 0.598 in females. Regression equation is calculated as; Stature = 2.887 x RFL + 95.82 in males and Stature = 2.427 x RFL + 99.46 in females.

Anjali P et al calculated mean left forearm length as 26.68 ±1.34 cms in males and 21.68 ±0.87 cms in females. Correlation coefficient was calculated as r = 0.65 in males and r = 0.68 in females. Regression equations to calculate stature were Stature = 2.92 x RFL + 93.45 in males and Stature = 2.37 x RFL + 113.89 in females.[12]

The present study observed almost similar results with mean left forearm length of 25.94±1.27 cms and 22.12±1.36 cms in males and females respectively. Positive correlation is found between stature and left forearm length in both the sexes with r = 0.500 in males and r = 0.651 in females respectively. Regression equations are; Stature = 2.128 x LFL + 116.5 in males and Stature = 2.632 x LFL + 95.08 in females.

Both right forearm length and left forearm length showed significant correlation with the stature in male and female population group. It is also evident from the Figures 3-6. Forearm lengths are positively and linearly related with the stature of an individual for left forearm.

Forearm length and hand length show high degree of correlation with stature of an individual in both the sexes. Percutaneous measurements of forearm is useful parameter in stature estimation. Thus these measurements can be used in regression equations formulated for that particular population to estimate height of an individual.

Conclusion

Anthropometry expresses quantitative relationship between stature and various body dimensions. The relationship that exists between stature and different body parts of an individual has been of great interest to the forensic and medico legal experts.

The present study has established definite correlation between stature and forearm length individually in both males and females included in the study.

Regression equations for each of parameter were derived as:

For Females:

1. Stature = 2.427 x Right forearm length + 99.46.
2. Stature = 2.632 x Left forearm length + 95.08.

For Males:

1. Stature = 2.887 x Right forearm length + 95.82.
2. Stature = 2.128 x Left forearm length + 116.5.

The above equations can be used to know the height of an individual and thus helps to determine the identity of an unknown. The anthropometric measurements differ in different sex and ethnic groups which are determined by genetic and environmental factors suggesting the need for different normograms for various populations.

These types of studies are of anthropological importance as it helps to know the difference between different population groups. If the study is repeated on the same population group after several years, it will help to identify the micro evolutionary changes. It also helps in forensic analysis in establishing the identity of the person in question, where stature is one of the primary characteristics of identification.

Conflict of Interest: None.

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