Original Research Article

ESTIMATION OF HEIGHT FROM MEASUREMENT OF PERCUTANEOUS TIBIAL LENGTH IN SOUTHERN PARTS OF WEST BENGAL

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ABSTRACT

Background: A close relationship between stature and dimensions of various body segments is of value in medico-legal investigation as well as in anthropology. A cross sectional study was carried out on 400 subjects (200 males and 200 females) in the South Bengal. Stature was measured by a "Standard anthropometric instrument". This study was carried out to investigate the relationship between height and tibial length among a group of males and females in South Bengal and to derive regression formulae between tibial length and height of an individual.

Result and main findings: Significant and positive correlation co-efficient was seen to exist between stature and measurement of tibial length in both male and female population. Their respective regression equations were also obtained in both sexes.

Conclusion: In this study, the correlation of height with tibial length is greater in case of male than female. Tibial length is greater relative to stature in men than women. Comparison was also made with the other population and this would contribute to the understanding of the relative status of our population in the context of anthropometric variants.

KEY WORDS: Anthropometry, Height, Tibial length, Correlation, Regression Equation.

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INTRODUCTION

Anthropometry is a series of systematic measuring techniques that express quantitative dimensions of the human body and skeleton. It is often viewed as a traditional and perhaps the basic tool of biological anthropology [1], but it has a long tradition of use in forensic sciences. 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].

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 ethnicity so that stature estimation becomes more reliable and identification of an individual is easily established. The aim of our study is to help in identification of victims of mass death due to natural calamities or man made disasters from fragmentary and dismembered human remains and to find if there is any sex and racial difference of height when compared to tibial length. The study also aims to find out any correlation of height with tibial length among male and female population of Southern parts of West Bengal and to predict and estimate height from tibial 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 (during June 2011-May 2012) selecting apparently healthy relatives of patients belonging to various regions of Southern Bengal, medical and paramedical students, staffs and various faculties of a Government Medical College in West Bengal. 400 persons (200 male and 200 female) within the age range between 18-35 years were chosen (as by the age of 18 a person attains his maximum height and amplitude; by the age of 35 a person usually does not reduce in size). The exclusion criteria were

- 1) Major ailments in the past affecting leg
- 2) Past history of injury, fracture, surgery of leg
- 3) Congenital or acquired deformity of leg or spines
- 4) Past history of generalized disease affecting height like rickets, osteomyelitis, gigantism, dwarfism, achondroplasia, cretinism etc.
- 5) Past history of major generalized illness that may affect growth and development in childhood.

After getting permission from the Institutional Ethical Committee, the samples were collected by attending various OPDS, departments and students' hostels. They were approached individually and the purpose and nature of the experiment were explained. Before performing any maneuver written consent was taken from each person. Measurements collected were height of the individual (in cm) and the tibial

length (in cm) using a Stature meter (a height measuring instrument), measuring tape and SPSS for statistical analysis of the collected data. Their left leg was measured as per recommendation of the International agreement for paired measurement at Geneva. All measurements were taken in a well lit room.

Tibial length for this study was taken as the distance between the point just below the joint line (between medial condyles of femur and tibia) to the tip of the medial malleolus. The subject sat with the left knee in semiflexed position and the left foot partly inverted to relax soft tissues and render bony landmarks prominent.

Height measurement:

Stature is the vertical distance between the point vertex and the heel touching the floor (ground surface). The stature meter was placed on the floor against the wall. The tape was pulled until '0' reaches the red line. This part was stuck to the wall and was fixed with the screws supplied. Person was asked to remove bulky clothing including thick soled shoes and hair ornaments. Person was requested to stand against a wall so that his/her back of head, rear and heels touched the wall. The person was directed to look forward with the head in the Frankfurt plane (the line joining the floor of external auditory meatus to the lower margin of the orbit). The stature meter was pulled down on to the subject's vertex in mid-sagittal plane to get the measurement without rounding up fractions of centimeters.

To avoid intra-observer variations,

1. Measurements were taken in a fixed time between 12 to 1:30 pm to eliminate diurnal variation
2. Measurements were taken by the same person to avoid interpersonal error in methodology
3. Same measuring apparatus were used throughout the study period

The data were collected, analyzed and subjected to statistical analysis using Statistical Package for the Social Science (SPSS version 20) to know the correlation of stature with tibial length. Simple linear regression equations were derived from various combinations.

RESULTS

Earlier the multiplication factor method was used for estimation of stature from anthropometric measurements of body. But now the most widely used method for estimation of stature from anthropometric measurements of body is by using regression equation. Worldwide regression formulae are accepted as of utmost importance in determination of stature from various anthropometric dimensions.

In the present study, formula derived this as under: Regression equation:

Height = value of constant (a) + regression coefficient (b) X tibial length

Regression equation of height (cm) versus tibial length (cm):

Male: Height (cm) = 123 + 1.24 X tibial length (cm)

Female: Height (cm) = 146 + 0.341 X tibial length (cm)

Table 1 and 2 show statistical analysis of anthropometric measurements of height and tibial length in both sexes separately. The values of all measurements of parameter in case of males are higher than in females and these sex differences are statistically highly significant. This can be attributed to the fact that fusion of epiphysis of bones occurs earlier in girls in comparison to boys. In other words boys have about 2 more years of bony growth than girls which were expressed in male somatometric measurements of adults. [5]

Table 1 shows average height for each sex within this population is significantly different with adult males on average being taller than adult females. It is stated that the gender difference in height may be attributed to sex chromosomal differences. Adult height between ethnic groups often differs significantly. For example the average height of women from the Czech Republic is currently greater than that of men from Malawi. This may be due to genetic differences, childhood differences or to both.

Table 2 illustrates the value of correlation between height and tibial length. In case of males it is 0.505 and in case of females it is 0.222. It is higher in case of males. So there is a stronger bond of correlation between these parameters

in males than in case of females.

Slope of the equation for males > slope of equation for females. Implies that for a unit change in tibial length, height of males will increase or decrease more rapidly than that of females.

Linearity suggests that relationship between the study variable and the independent variable. It is linear in nature i.e. of the form $y = a + bx$. If curvilinear (e.g. – quadratic or 3rd degree or above) it suggests change in study variable is more rapid for unit change in the independent variable.

Inspection of the regression equation reveals that for a given tibial length females are predicted to be taller than males. Hence tibial length is greater relative to stature in men than in women.

Tibial length as a proportion to stature is calculated by obtaining the inverse function of regression equation –

For male: tibial length = (height – 123) / 1.24

For female: tibial length = (height – 146) / 0.341

For a given height, male tibial length is significantly larger than female.

Fig. 1: Correlation of height and tibial length with fitted regression line of height in case of males.

Fig. 2: Correlation of height and tibial length with fitted regression line of height in case of females.

Fig. 3: Stature Meter. **Fig. 4:** Height measurement. **Fig. 5:** Joint line. **Fig. 6:** Tibial length measurement. **Table 1:** Range, Mean and Standard Deviation of height in both male and female.

Headings	Males	Females
Total number	200	200
Height (cm)	152.4 – 187.3	138.7 – 171.5
Mean Height (cm)	167.624	157.448
Standard Deviation of height	7.05901	5.55669

Table 2: Range, Mean, Standard Deviation of tibial length, value of constant(a), correlation coefficient (r), Regression coefficient (b).

Heading	Males	Females
Tibial length range (cm)	29.8 – 42.7	27.6 – 38.6
Mean tibial length	36.0861	33.5017
Standard Deviation tibial length	2.87553	3.62343
Correlation coefficient (r) height and tibial length	0.505	0.222
Regression coefficient height and tibial length (b)	1.24	0.341
Value of constant (a)	123	146

DISCUSSION

There are a lot of variations in estimating stature from limb measurements in different studies in different races.

A study was conducted by Bhavna, Surinder Nath in 2009 [8] on use of lower limb measurements in reconstructing stature among Shia Muslims. In both sexes correlation of tibial length with stature was 0.765 and regression equation was $\text{Height} = 84.74 + 2.27 \times \text{tibial length}$. It was observed that tibia exhibits the overall highest value of correlation with stature followed by fibula and femur length. So a bone, which correlates highly with stature would provide more accurate estimation of stature as compared to the one that has relatively low correlation with stature.

Chikhalkar BG, Mangaokar AA, Nanandkar SD, Peddawad RG [9] conducted estimation of stature from measurement of long bones. Correlation of stature with knee to ankle length = 0.2086 which is in contrary to study of Bhavna et al. Regression equation was $\text{Height} = 156.543454 + 0.296018 \times \text{knee to ankle length}$.

Banerjee M, Samanta C et al [10] conducted estimation of height from the length of tibia on 50 male and female subjects in West Bengal. For males correlation coefficient was 0.926 and regression equation was $\text{height} = 71.361 + 2.575 \times \text{tibial length}$. In case of females correlation coefficient was 0.948 and regression equation was $\text{height} = 65.344 + 2.6918 \times \text{tibial length}$.

CONCLUSION

The present study was done on 400 people belonging to southern parts of Bengal over a period of one year. The heights of male and female individuals were correlated with their corresponding tibial length. The mean height of

males (167.624cm) was more than the mean height of females (157.448 cm) in the study group and also the mean tibial length in males (36.0861cm) was higher than those in females (33.5017cm). In our study it was also observed that the tibial length exhibits high value of correlation ($r=0.505$ in males and 0.222 in females) with stature. Also the correlation coefficient of height with tibial length is higher in males as compared to those in females. So the tibial length correlates highly with stature estimation. The heights of males and females can be derived from the tibial length by using the regression equation derived from this study. For males : Height (cm) = $123 + 1.24 \times \text{tibial length (cm)}$ and for Females : Height (cm) = $146 + 0.341 \times \text{tibial length (cm)}$. Thus this study establishes an equation to derive the height of an individual merely by the measurement of tibial length. This equation can especially be helpful when applied for dismembered or fragmented body parts, as is commonly encountered in disaster sites. An attempt was also made to compare the findings with similar relevant studies in Indian population of different regions and ethnicity. Further studies can be done by considering bigger population from diverse regions of Bengal by taking other measurements as well, which will help to establish similar equations applicable to the Bengali population in general.

However certain limitations of the study are

- a) In the present study age range of only 18 – 35 years is considered.
- b) Sample size is 400. It would have been wiser to increase the sample size as much as possible to get a more accurate result and eliminate biasness.
- c) Measurement of only healthy individuals are considered. Hence the data may not be applicable to individuals who are malnourished and/or suffering from congenital structural malformations.
- d) Applicability of anthropometric measurements in living and deceased individuals may practically differ.

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Conflicts of Interests: None

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