Original Research Paper

Estimation of Stature from Radiological Measurement of Sternal Length with Corroboration in Living Individuals A Study in Contemporary Bengali Adults

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Abstract

The role of Forensic anthropology to derive alternative and newer modes of identification is increasing every day. The simple and inexpensive means of measurement of radiological length of sternum from digital radiographs and its use to estimate stature in a contemporary Indian (Bengali) population is the aim of this study. By generation of linear regression equations for male and female from this data we propose to estimate the stature and compare the same from the stature available from measurement of the individuals. Thus we shall be able to predict the accuracy with which such projection from radiological assessment is applicable. In this study the standard error of estimate for the male model is 2.943 and correlation coefficient is 0.636. The r square for the model is 0.4. In this study the standard error of estimate for the female model is 2.230 and correlation coefficient is 0.843. R square =0.7.

The present investigation shows that estimation of stature by this method has its shortcomings in terms of accuracy and therefore be used only as an alternative for practical Forensic purpose.

Key Words: Forensic anthropology, Stature estimation, Sternal length, linear regression

Introduction:

Physical anthropologists and Forensic pathologists have always given great importance to the methods of stature estimation from long bones. Often in Forensic investigations it is seen that mutilated bodies, few bones or fragments of bones are presented to the investigator.

Earlier works done by Trotter and Glesser [1] have been monumental. This has given rise to newer research on the topic. Several such investigations have been documented.[2-8]The human sternum have been the subject of extensive research on morphometry and their application on stature[9,10], age[11-13] and sex. [14-18]

Several population specific studies have been reported showing consistent results. [19, 20]Population specific studies done on estimation of stature from fragment of tibia [21] and bicondylar width [22] and maximum length of femur in Bengali population help us to form a preliminary idea on the applicability of regression equation from long bones in regional population.

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Recent works have been done on development of regression formula for estimation of stature from sternum by J.Singh et al on North-western Indians [11] and by Menezes et al on south Indian females. [10]

Those researchers have suggested population specific regression equations to estimate stature in Indians.Studies on specific populations done by radiological measurement of sternal length with correlation in cadaver length in Spaniards [14] have reported standard error of estimate of 6.2 and 5.56 in male and female subjects respectively.

This present study was designed to develop a population specific regression formula (Regression equation) to correlate the stature of an individual with length of sternum measured by digital radiography.

After searching available literature to the best of our ability, this preliminary study is perhaps the first work done on correlation of stature in living individuals to the radiologically measured sternal length.

We propose to see whether in absence of the entire skeleton this process can help to solve medico-legal problems giving due consideration to regional factors.

Aims and Objectives:
1. To derive a mathematical model to preliminarily test whether radiological length of sternum measured from chest radiograph

can be correlated to stature measured in living individuals.

2. To observe as to whether a relatively inexpensive and easily available technique as digital radiography is useful for this purpose.
3. To test its reliability as a test for estimation of stature in a regional population
4. To test the population specificity of the model.

Material and Methods:

A population consisting of students and residents who are registered with the B.C.Roy technology central government hospital was selected for this study as it has a heterogeneous mixture of people of Bengali origin along with people from all ethnicities because of students and teachers from all parts of India associated with the institute.The study design is cross sectional.

Random samples were selected from patients/healthy volunteers who agreed to participate in the study when explained the risk/benefit factors of the study. The radiographs for the study were conducted at the hospital from June to December 2014 for a study period of approximately 6 months. The results and statistical analysis was done at Department of Forensic medicine BMC, Burdwan.

Consent was taken from the patients or their relatives for the use of their data for research purposes. The data used in this study was obtained from patients/volunteers who underwent lateral radiograph examination in the radiology department of the hospital. The data consists of 102 individuals from 16 years age to 89 years. Of the population were 59 males and 43 females. Living height was taken by measurement in stadiometer.

X-rays were done in care stream direct view vita CR.Sternal dimensions were recorded from digital images using measurement tools included within the image analysis software program associated with the care stream CR 4.51 digital system radiographic system. The exposure given was 65 Kva 0.4 s and 24-30 mA.

The distances between chest plate and tube are 90 cm. The digital images were obtained and then studied altering the contrast and using filter to enhance the visualization of the sternum as whole. The sternal length was measured in two parts by the software provided tools.The magnification error (20% zoom) due to digital radiography was calculated and the length was accordingly calculated reducing the 20% as final sternal length used for the study.

A test for repeatability of the measurements was first performed before the data was subjected to statistical analysis by recording the lengths a second time at an interval of 3 weeks. Mean intra-observer error was 1.3% for both dimensions. Length of sternum was measured in two parts:

1. The distance from suprasternal notch (A) to manubrio-sternal junction(B)=(M) and
2. The distance from manubrio-sternal junction (B) to xiphoid(C) = (B) and Then added to get the total sternal length (M+B).

Fig. 1: Measurement of Length of Sternum

Observations and Results:

In this study Out of total 102 cases of Bengali origin 59 were males and 43 were females. These were used to get the regression model. We included 10 cases of Bengali origin and 10 cases of other ethnic origin in the study to test the applicability of the obtained model in a geographically different ethnic population.

The data being normally distributed was tested by Shapiro-wilk test and P-P plot. The p value was significant (0.121 for males and .000 for females). Then the data was subjected to statistical analysis using SPSS 20.0 version. The analysis was done by bivariate linear regression.

Independent variable was length of sternum.Dependent variable is stature of the individual.Being linear this follows the equation y=c+mx.The stature was calculated in males as 137.58 + 1.15 *sternal length. The standard error of estimate is 2.94.

The stature was calculated in females as 120.47 + 1.81* sternal length. The standard error of estimate is 2.23.Thus from this study it can be derived that a large percentage of cases the stature can be calculated within 95% confidence intervals of the predicted value.

In this study the standard error of estimate for the male model is 2.943 and correlation coefficient is 0.636. The r square for the model is 0.4. In this study the standard error of estimate for the female model is 2.230 and correlation coefficient is 0.843. R square =0.7.

The stature was calculated in males as stature (cm) =137.58 + 1.15 *sternal length.

The stature was calculated in females as stature (cm) = **120.47 + 1.81* sternal length**.

Table 1: The coefficients of regression

	Males	Females
R	0.636	0.843
R Square	0.405	0.711
Std. error of estimate	2.943	2.230

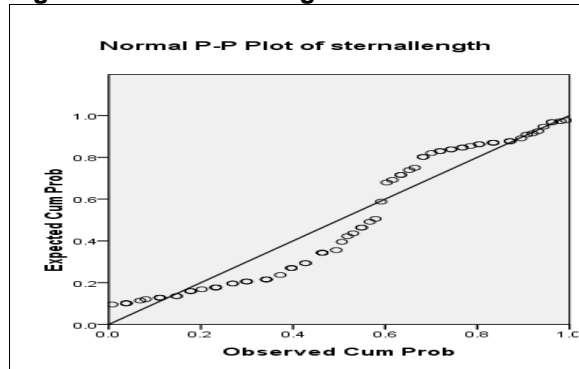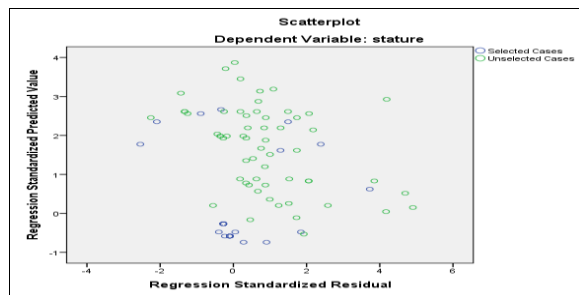**Fig. 2: P-P Plot Showing Normal Distribution**

Fig. 3: Scatter Plot showing normal distribution of predicted values

Discussion:

Earlier studies [10,11,012,13]done on North Western Indian population, south Indians and Portuguese have helped to develop population specific regression formula for estimation of stature of an individual from various parameters of sternum. The results obtained in the present study show that It was possible to predict with greater accuracy (70%) stature from sternal length in females (value of R is 0.84 and R square 0.7) of cases in contemporary Bengali adult population**.**

This prediction was however less accurate in males (value of R is 0.636 &R square 0.4) of cases in contemporary Bengali adult population. The standard error of estimate is 2.94 for males and 2.23 for females thus it cannot distinguish persons of nearly similar stature .Rather it can be used to give preliminary discerning information regarding the stature. This is consistent with results from studies on Spanish population. [14]

The correlation coefficient and standard error of the estimate values obtained in the current study are generally comparable to those observed in previous investigations [8-14] that assessed the efficacy of sternal measurements for stature estimation in other population groups.

Marinho and colleagues [12] reported a correlation coefficient of 0.329 and a standard error of 6.59 cm for the length, including the xiphoid process, of fresh sterna in a male sample from Portugal. Similarly, Singh et al, in their study of a Northwest Indian population sample, obtained correlation coefficient values of 0.316 for males and 0.328 for females for regression models based on sternal length taken from dry bone specimens.

The corresponding standard errors of the estimate for these regression models were 6.83 and 6.65 cm for males and females, respectively. Menezes et al obtained higher correlation coefficients and lower standard errors of the estimate for regression models derived from the combined length of the manubrium and meso-sternum recorded from dry bone specimens in a South Indian sample. [9]

For the male sample, the correlation coefficient was 0.638 and the standard error was 5.64 cm, whereas for the female sample, these two values were 0.639 and 4.11 cm, respectively.

Our present method is relatively simple and inexpensive technique for estimation of stature when data from long bones are not available. Thus it can be concluded that sternal measurements obtained from digital radiographs used for estimation of stature cannot be taken as a highly reliable method.

One limitation of the present investigation was that the sample was small. This can be mitigated by a larger study to examine the applicability of the results for use in Forensic practice.

This model when applied to different regional population shows a much lower predictive value. This regional variation agrees with previous studies. [9-14]

Separate models must be developed for different populations for accurate prediction of stature from sternal measurements.

Further research will add to the corpus of ever-growing knowledge in physical anthropology and Forensic Medicine.

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