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Research Paper: Correlation of Posterior Curve Length of Sternum and Stature: A Postmortem Study in Delhi Population

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ABSTRACT

Background: The primary characteristics to establish the identification of an individual are sex, age, and stature [1]. Determination of stature is easy if a complete body or the entire skeleton is found. When only some parts of the body or skeleton are available, it is necessary to have different formulae for determination of stature from their osteometric measurements. The present study aims to assess the stature of an individual from his or her sternum with the help of Posterior Curve Length (PCL).

Methods: The study was conducted on 100 cadavers, including 50 females and 50 males, died 18 years or older age. The cases were referred for medico-legal postmortem examination to the Department of Forensic Medicine, Maulana Azad Medical College, New Delhi. Sternum samples were obtained during autopsy (as fresh sternum) and after removal of muscular coverings, cleaned and dried at room temperature (as dry sternum) for the study. PCL was measured and linear regression was used to recognize sternum correlation with stature.

Results: In our study which was conducted on fresh and dry samples of sternum, the stature can be estimated by 68% accuracy with linear regression equation of Y=91.51+3.5 (Posterior Curve Length of fresh sternum) with standard error±3.5 cm and correlation coefficient of 0.872. Also the stature can be estimated through Y=96.1+3.4 (Posterior Curve Length of dry sternum) with standard error of ±3.9 cm and correlation coefficient of 0.610.

Conclusion: From the present study we found some synergistic factors which are helpful for estimation of stature from respective PCL of sternum which clearly shows that sample of sternum obtained from decomposed body, or in cases where long bones are missing, PCL of sternum acts as an alternative to estimate stature in Delhi population.

1. Introduction

Identification is the determination of the individuality of a person based on certain physical characteristics [1]. Question of identification in living people arises in criminal cases such as assault, murder, rape, swapping new-born babies in the hospital, and impersonation. In civil cases like marriage, inheritance, insurance claims, disputed sex, etc. identification plays an important role [2]. In

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establishing the identity of an individual, primary characteristics of identification are sex, age, and stature [1]. Determination of stature is an easy task if a complete body or the entire skeleton is available. When only some parts of the body or skeleton are available, it is necessary to have different formulae for determination of stature from their osteometric measurements. Nutrition, genetics, environment, socioeconomic status, etc. are those aspects that decide the stature of a person [3].

But the length of each part of the human body has specific correlation with the height of a person. Using this fact, the stature can be calculated to some extent. Sternum is a superficial bone which can be easily procured from cadavers during autopsy, hence the present study attempts to assess the stature of an individual from sternum with the help of Posterior Curve Length. This research provides quantitative results to strengthen the reliability of sternum as a potential tool for stature estimation in Delhi population.

2. Materials and Methods

The study was conducted on 100 cadavers, including 50 females and 50 males died at 18 years and older age. The cases were referred for medico-legal postmortem examination to the Department of Forensic Medicine, Maulana Azad Medical College, New Delhi. In each case, selected for the study after ruling out exclusion criteria (fractured and diseased/deformed, burnt sternum) consent has been taken from the legal guardian of the dead body. Height was measured in lying position using measuring tape. The thorax was opened using routine standard autopsy technique and sternum was taken out after sectioning it at the costochondral junction (fresh sternum).

The clavicles were disarticulated from the sternum at sternoclavicular joints. The sternal margins that articulate with the cartilages of the first seven pairs of ribs were carefully cut so that the body could be measured with precision (fresh sternum). Measurement was taken keeping the fresh sternum bone on flat surface. The length of Posterior Curve Length (PCL) was measured between suprasternal notch and the xiphoid process (Figures 2 and 3).

Direct measurements were taken by measuring tape with readings with 1 mm precision. Three readings were taken and their average was recorded. After taking direct measurements, the sternum was boiled carefully for 15 minutes or until its muscular coverings were detached, in a solution containing sodium chloride and detergent. After removal of muscular coverings, the sternum was cleaned and dried at room temperature (dry sternum). Repeated measurements were taken and tabulated. Data were summarized as mean and standard deviations and linear regression equation was used to estimate the correlation of stature with the help of PCL of sternum. The obtained data were analyzed using SPSS 20. Examined by Shapiro-Wilks, Kolmogorov-Smirnov, and Q-Q plot tests, it was found that the data were distributed normally. The P value was significant at less than 0.05 (Figure 1).

3. Results

In case of fresh sternum, the mean PCL of sternum was 19.3 cm in 100 cases. In males and females the mean was 20.40 cm and 18.72 cm, respectively. Similarly for dry sternum the mean PCL was 17.74 cm (Table 1). The mean height of the subjects was 159.4 cm in 100 cases. The mean height for males and females were 162.76 cm and 156.14 cm, respectively (Table 1).

Simple linear regression was calculated to predict stature based on PCL of fresh sternum. Dependent variable is stature of the individual. A significant regression equation was found as stature Y=91.51+3.5 (PCL) with [F(1.1)=327.4, P<0.001], with R^2=0.770 (Table 2). Predicted height of individual is equal to 91.51+3.5 (PCL); where height and PCL is measured in centime-

Table 1. Descriptive statistics of Posterior Curve Length (PCL) and height of study subjects (all measurement in cm)

		Number of Case	Minimum	Maximum	Mean	Std. Error	Std. Deviation
PCL	Fresh	100	15.46	22.66	19.3 (M=20.41; F=18.27)	0.16	1.64
	Dry	100	14.46	21.83	17.74 (M=19.16; F=16.3)	0.18	1.81
Height		100	143.00	178.00	157.9 (M=162.76; F=152.8)	0.47	7.3

M=Male; F=Female

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Table 2. Regression analysis calculated for fresh sternum

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
Constant	91.511	3.582		24.8	0.001
[a] Posterior Curve Length in fresh sternum	3.541	0.196	0.877	18.0	0.001

[a]. Dependent variable: stature of individual

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Table 3. Regression analysis calculated for dry sternum

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
Constant	96.163	3.96		25.3	0.001
[a] Posterior Curve Length in dry sternum	3.47	0.213	0.855	16.30	0.001

[a]. Dependent variable: stature of individual

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tre, average height increases 3.5 cm for each 1 cm of PCL and 91.51 cm is constant. The standard error of estimate is 3.50. By applying the standard error 3.50, we can determine the stature of an individual with 68% confidence. If we multiply the standard error of estimate by 2, stature can be estimated with 95% confidence. Similarly, for dry sternum a significant regression equation Y=96.16+3.4 (PCL) (dry sternum) was found with [F(1)=266, P=<0.01] and R^2=0.731 (Table 3). When height and PCL is measured in centimetre, average height increases is 3.4 cm for each 1 cm of PCL and 96.16 cm is constant. The standard error of estimate is 3.9. By applying the above error, we can determine the stature of an individual with 68% confidence.

Table 3 clearly shows that, the fresh sternum PCL has higher correlation (fresh sternum [0.87]; dry sternum [0.61]) to stature than that of dry sternum. Considering sex, in both dry and fresh sternum, male stature significantly correlated (correlation coefficient =0.80 and 0.6) with PCL as compared to female (correlation coefficient =0.75 and 0.60) cases (Table 4). Statistical data indicate that the fresh sternum is more reliable than dry sternum for stature estimation by use of PCL. The possible reason

Table 4. Result of linear regression equation for the present study

Present Study		Standard Error of Estimate	R^2	Correlation Coefficient	Sig.	Linear Regression Equation
Fresh sternum	Male	3.61	0.647	0.809	<0.01	Y=101.4+3.5 (PCL)
	Female*	3.2	0.571	0.755	<0.01	Y=55.86+5.5 (PCL)
M+F combined (fresh sternum)		3.5	0.770	0.872	<0.01	Y=91.51+3.5 (PCL, fresh sternum)
Dry sternum	Male	3.80	0.611	0.621	<0.01	Y=99.4+3.3 (PCL, dry sternum)
	Female	3.9	0.368	0.606	<0.01	Y=84.7+4.1 (PCL, dry sternum)
M+F combined (dry sternum)		3.9	0.731	0.610	<0.01	Y=96.1+3.4 (PCL, dry sternum)

M=male; F=female; Y=stature

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Table 5. Relation of stature and sternum reported by various authors

Studies		Standard Error	R^2	Correlation Coefficient	Linear Regression Equation
Menezes RG [5]		4.11	-	0.639	Stature=111.599+(3.316×Length of the sternum)
Choudhry et al. [6]		2.94 (M)	0.4	0.636 (M)	Y=137.58+1.15 * sternal length
		2.230 (F)	0.7	0.843 (F)	Y=120.47+1.81 * sternal length.
Singh et al. [7]		6.83 (M) 6.65 (F)	-	0.316 (M) 0.328 (F)	-
Manoharan et al. [8]		4.8	-	0.78	Y=93.6+5.1* (combined length of manubrium and sternum)
Present study	1. Fresh sternum	3.5	0.770	0.872	Y=91.51+3.5 (Posterior Curve Length fresh sternum)
	2. Dry sternum	3.9	0.731	0.610	Y=96.1+3.4 (Posterior Curve Length dry sternum)

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might be that the fresh sternal junction points are held in place by soft tissues covering at junction sites (manubriosternal and xiphisteranal joints), so possibility of error in measurement is low but in dry sternum many a times boiling (as used in this study to remove soft tissues) or decomposition may lose the xiphoid process or manubriosternal joint from the body in non-ossified sternums.

4. Discussion

The sternum, commonly known as the "breastbone" is a flat bone that lies in the middle of the rib cage. Morphologically the sternum is naturally curved with a convex anterior surface and a concave posterior surface [6]. Its importance in forensic anthropology for determining the identity of human remains is well known. Many studies have derived various indices and formulae from sternum to determine the age, sex, and stature. However, there are only a handful of studies on stature determination of an individual using this bone [5-9]. Most of the studies are based on measurements of length of the body and manubrium of sternum [5-9]. Earlier studies [6, 8, 9] done on Northwest Indian population, South Indians, and Portuguese have helped develop population specific regression

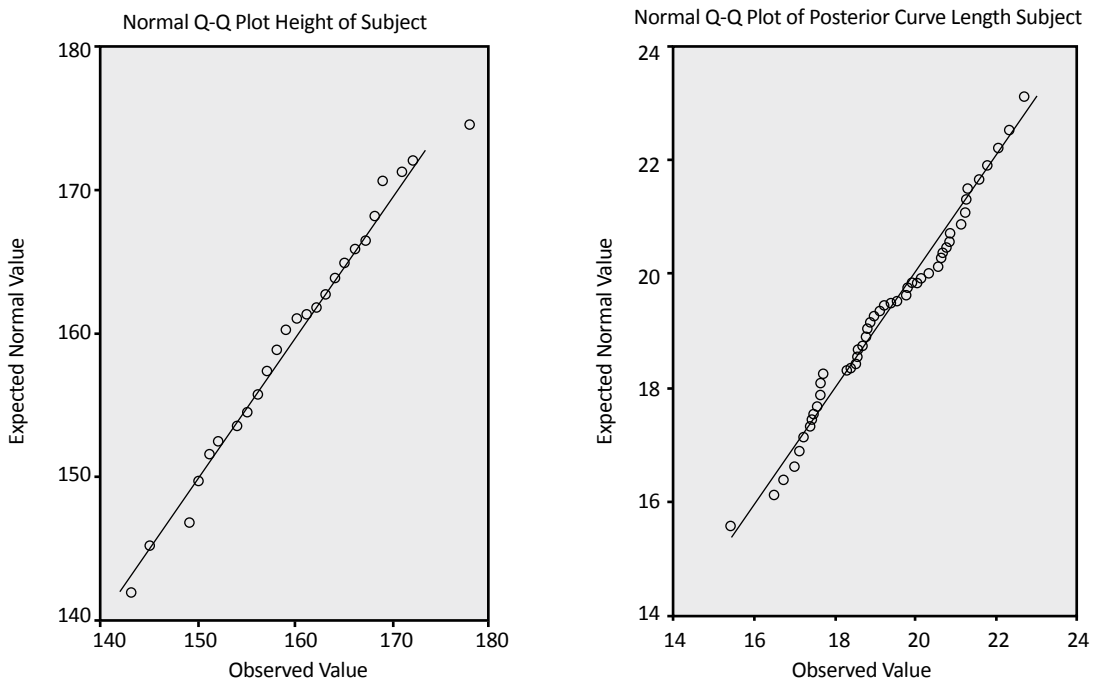

Figure 1. Q-Q plot test for height and posterior curve length

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Figure 2. Measurement of posterior curve length in dry sternum

Figure 3. Measurement of posterior curve length in fresh sternum

formula for estimation of stature of an individual from various parameters of sternum. One study has included the xiphoid process in the measurement in fresh samples [9].

In our study which was conducted on fresh and dry sample of sternum, the stature can be estimated by 68% accuracy with linear regression equation Y=91.51+3.5 (PCL fresh sternum) with standard error of ±3.5 and Y=96.1+3.4 (PCL dry sternum) with standard error of ±3.9 (Table 5). Marinhano et al. [9] used fresh and skeletonized length of sternum to estimate the correlation with stature. In their study, the regression model provided at 95% confidence interval of 13.32 cm and a correlation coefficient of only 0.329. Similar to this, we used PCL of fresh and dry sternum to estimate the correlation with stature with correlation coefficient as 0.872 and 0.610 and standard errors as 3.5 and 3.9 cm, respectively, which showed that the correlation coefficient was higher in fresh and dry sternum as compared to study by Marinhano et al. [9] and fresh sternum is more reliable as compared to processed sternum.

Menezes et al. [5] studied the sternal length and a linear regression equation [Stature=111.599+(3.316×Length of the sternum)] was derived to estimate stature from the length of the sternum. The correlation coefficient was 0.639. The standard error of the estimate was 4.11 cm. Manoharan [8] also studied combined length of manubrium and sternum and found the correlation coefficient of 0.639 and standard error of the estimate as 4.8 cm. As compared to both studies [5, 8], in our study the correlation coefficient was higher and standard errors lower.

Choudhary et al. studied radiological measurement of sternal length in Bengali population. In their study, the standard errors of estimate for the male and female model were 2.943 and 2.230 cm, respectively and correlation coefficients were 0.636 and 0.843, respectively that compared to our study they found lower correlation coefficient and higher standard errors [7].

Singh et al. studied 252 male and 91 female sternums and found that the stature of males can be predicted with SEE of 6.66 (R^2=0.16, r=0.318) from combination of MBL+BL_3+LM+BL_2, and in females from MBL only, it can be estimated with SEE of 6.65 (R^2=0.10, r=0.318). In our study, fresh and dry sternum from males has standard error of 3.5 and 3.8 which is lower as compared to study of Singh and associates [7].

5. Conclusion

From the present study we found some synergistic factors which are helpful for estimation of stature from respective PCL of sternum which clearly shows that sample of sternum obtained from decomposed body, or in cases where long bones are missing, PCL of sternum acts as an alternative to estimate stature in Delhi population. This method is relatively simple and inexpensive for stature estimation. As India has regional population each groups needs further research which will add to the growing knowledge in physical anthropology and Forensic Medicine field.

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Conflict of Interest

The authors declared no conflicts of interest.

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