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Estimation Of Female Stature From Sternal Measurements -An Autopsy-Based Study In Western Haryana.

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Abstract:
Background*: Identification refers to the determination of individuality of a person. It is based on certain physical characteristics unique to that individual. Personal identification is an important process in legal proceedings. This study aims to investigate the sternum, a potential reliable indicator in stature estimation of adult female, with the help of regression analysis.*
Materials and Methods*: The present descriptive observational study was conducted on 39 female cadavers of age more than 25 years brought for medicolegal autopsy in this tertiary care center located in Western Haryana. The aim of the present study was to find out a correlation between the lengths of different parts of sternums and stature and derive a simple linear regression equation for stature estimation from the length of the sternum. The aim of study to investigate the sternum, a potential reliable indicator in stature estimation of adult female, with the help of regression analysis.*
Results*: In the present observational autopsy study, sternal measurements were obtained from 39 deceased female. Mean of the stature 156.7± 7 cm. The mean total sternal length was 157.16 ± 10.63 mm. Maximum variability (44.2%) was explained when stature was regressed on length of mesosternum. A significant correlation ($p<0.001$) with stature was shown by all the measurement except length of manubrium.*
Key Words: *Autopsy, Identification, Regression Analysis, Stature, Sternum,*

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I. Introduction

Identification refers to the determination of individuality of a person. It is based on certain physical characteristics unique to that individual.[1] Personal identification is an important process in legal proceeding. According to disaster victim identification guidelines of Interpol, DNA fingerprints, and dental profiles are the primary criteria of victims' identification and only one matching method is enough for definite identification.[2]

Biological profiles of the deceased, which consist of ancestry, age, sex, and stature, are valuable data that assist to narrow down the number of possible missing persons. Stature is a valuable piece of biological profile information, that may provide a vital clue of the personal identification process regarding the unknown deceased or missing person.[3]

The stature is directly proportional to different body parts and hence, shows a definite biological and genetic relation with each other. Long bones and their fragments have been extensively studied for determining stature. The most reliable long bone for estimating stature is the femur. Since long bones are not always recovered, estimation of stature has been done using other bones like cranium, vertebra and bones of the hand and foot.[4-7.]

In forensic cases, stature (or body height) is usually estimated using 'anatomical' and 'mathematical' techniques. The former method uses the sum of length of all the bones from cranium to foot with soft tissue correction[8]. The mathematical method calculates the stature from the length of the one or more bones by using regression analysis. So, it has the advantage over the anatomical method because it does not require complete set of bones to determine stature. Researchers have established a relationship between stature and measurements of different body parts which are often represented using linear regression equation derived from them.[9]

The skeletal characteristics vary with gender and region. Formulae developed in one region may not be acceptable for other regions. Hence, there is a need for studies to be conducted for each population group and for each gender to derive population and gender specific formulae.[10-11]

This study aims to investigate the sternum, a potential reliable indicator in stature estimation of adult female, with the help of regression analysis in region of Western Haryana. Correlation of measurement of different part of sternum bone with the stature will be obtained to develop the regression equation.

II. Material And Method

This observational study was conducted after taking approval from the institutional ethical committee. Medicolegal autopsy cases of adult female of age > 25years whose identity was ascertained with valid documentary proof of age were included in the study. Informed consent was taken from the relatives prior to the study. A total of 39 female cases of were recruited with convenient sampling method during the study period.

Study Design: A cross - sectional observational study.

Study Duration: A one-year study from 1 January 2023 to 31 December 2023.

Study Area: In Department of Forensic Medicine and Toxicology, Maharaja Agrasen Medical College, Agroha, Hisar. Haryana (Western Haryana).

Sample Size: 39

Sample Population: All the medicolegal cases brought at mortuary of western Haryana

Inclusion Criteria:

1. Medicolegal autopsy cases of adult female of age > 25years whose identity was ascertained with valid documentary proof of age were included in the study.

Exclusion Criteria:

1. Fractures or obvious bony deformity of the sternum,
2. Showing signs of decomposition.
3. Completely charred or mutilated cases.
4. Transgender
5. Unknown cases.

Procedure methodology:

The stature of the deceased was first measured in supine position with a measuring tape from vertex of the head to heel and recorded in centimetre (cm). Rigor mortis was break before taking the measurement.

The sternum was removed as a single piece by putting the incision at the sternoclavicular joints and at the costochondral junctions. The sternum thus removed, was cleaned thoroughly to remove the soft tissue as much as possible. Sternum than put in sodium hydroxide (7-8 gm in per litter) solution and boiled for 60 -75 minutes. Adhered portions of cartilage or soft tissues were removed with the help of forceps and by gentle scrubbing with a soft brush. The specimens were then spread out on a clean piece of cloth for drying. 2 to 3 days were required for proper drying of the specimens. Measurements were taken thereafter. The digital Vernier calliper was used to take sternal measurements and were recorded in millimetres (mm).

The following sternal parameters were measured:

A. Length of Manubrium (M): Distance from centre of suprasternal notch to centre of manubrio-sternal junction (Anterior surface of Angle of Louis in midsagittal plane)

B. Length of Body of Sternum/mesosternum (B): Distance from center of manubrio-sternal junction to center of xiphisternal joint.

C. Combined length of Manubrium and Body (CL): Sum of M+B

D. Total Sternal Length (TLS): Sum of C+ Distance from centre of xiphisternal joint to tip of xiphoid process.

Fig 1. shows A. Schematization of the sternal lengths measured in this study (Singh et al. 2011), B. Length of Manubrium (M), C. Length of body of sternum/Mesosternum (B), D. Total Sternum Length (TSL).

Statistical analysis

The findings were recorded, and the data entry was done with the help of Microsoft Excel 365. Analysis of data was done using windows-based SPSS version 20.0 (Armonk NY: IBM Corp). The descriptive analysis was done to obtain mean, standard deviation (S.D) and range of the sternal measurements. Pearson's correlation was performed to determine the relationship between stature and sternal measurements. Univariate regression models were derived for each of sternal measurement. For regression analysis, stature was taken as the dependent variable while, the independent variable was different sternal lengths as mentioned earlier. The R^2 coefficient of determination was calculated to assess the significance of regression. The higher the value of R^2, the better the fit was and the more useful the regression equation was for prediction. The standard error of estimate and 95% confidence intervals for regression were computed. Statistical significance (p-value) was defined as $\alpha = 0.05$.

III. Results:

The mean age of the study sample was 46 ± 16 years ranging from 25 -75 years. The stature ranged from 142 to 170 cm, with a mean of 156.7± 7 cm. All sternal measurements showed a positive correlation with stature and except manubrial length this correlation was significant. The weakest correlation with stature was observed with length of manubrium (0.127) and strongest correlation of stature was observed by length of body of sternum (mesosternum) (0.665) (Table 1).

Table 1. Descriptive statistics of stature and different sternal measurement

Parameters	Mean ± SD	Correlation Coefficient with Stature	p- value
Stature (cm)	156±7	1	
Length of manubrium (mm)	48.06±4.05	0.127	0.441
Length of body of sternum (mm)	84.31±6.98	0.665	<0.001
Combined sternum length (mm)	132.33±9	0.579	<0.001
Total length of sternum (mm)	157.16±10.63	0.592	<0.001

A linear regression formula was obtained for different sternal measurements as shown in figure 2 to 5, denoted by Y=aX+b, where 'a' is the regression coefficient of slope or independent variable (sternal lengths), 'X' is the sternal measurement and 'b' is the regression coefficient of intercept/or dependent variable (stature). There was a moderately positive correlation between all the sternal measurements with the cadaveric length.

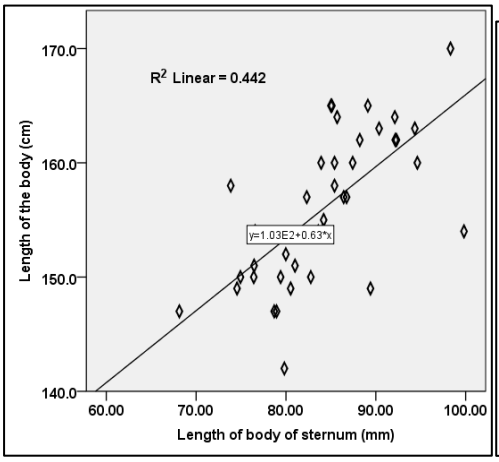

Fig 2. Correlation of the manubrium with stature

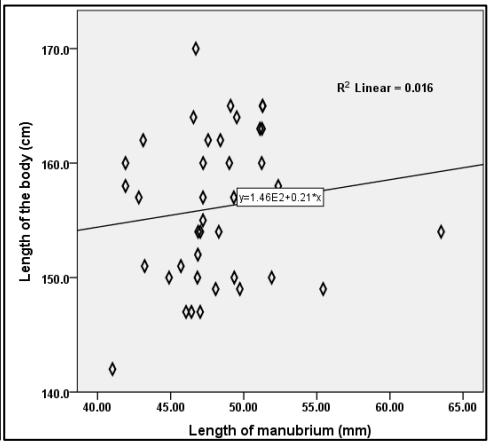

Fig 3. Correlation of the mesosternum with stature

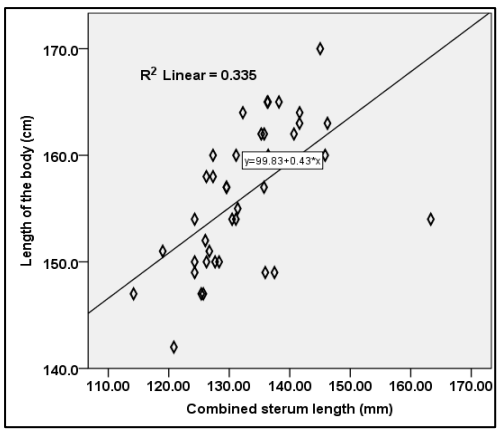

Figure 4. Correlation of the combined length of manubrium and mesosternum with stature

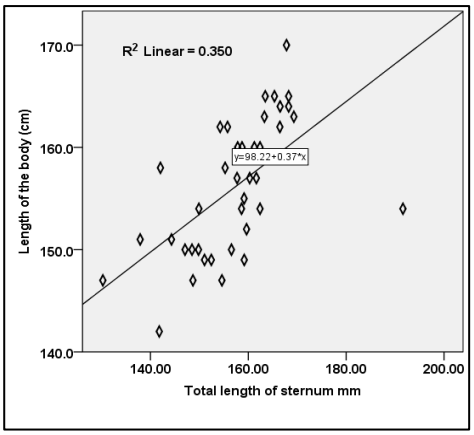

Figure 5. Correlation of the total sternal length with stature

Table 2. Linear regression model to prediction stature of female

Sternal parameters.	R^2	SEE (cm)	Predictive Equation for Stature Estimation
Length of manubrium	0.016	6.645	Length in cms=146.108+0.207 x (LMB in mm.)
Length of body of sternum	0.442	5.003	Length in cms=102.947+0.63 x (LMS in mm.)
Combined length of manubrium and mesosternum	0.335	5.464	Length in cms=99.83+0.425 x (CMM in mm)
Total length of sternum	0.35	5.401	Length in cms=98.219+0.368 x (TSL in mm)

The standard error of the estimate was calculated for all the sternal measurements as shown in table 2 and was found to be lowest in mesosternal/ body of sternum length i.e., 5.003 followed by total sternal length (5.401), the combined length of manubrium and mesosternum (5.464) and manubrium length (6.645). Overall analysis showed that the equation derived from length of body of sternum has the highest R^2 value i.e., 0.442 followed by TSL (0.35), the combined length of manubrium and mesosternum (0.335) and manubrium length (0.016). Simple linear regression model was derived for estimation of stature from each sternal parameter.

IV. Discussion

The overall evaluation of the literature supports that sternal lengths may be useful for estimating stature when long or other bones are not available.[9] The sternum has a firm structure to protect the underlying vital structures (lungs, heart and large blood vessels) from physical trauma thus, often remains intact in the postmortem period.[12]

Previous researchers have developed regression equations by regressing the stature of the individual to Sternum.

This is the first autopsy-based study from Western Haryana region to estimate stature from all the sternal parameters including xiphisternal length.

Researchers those used dry macerated sternum in their study were included to compare the results of present study. Following table summarises the results of various studies conducted to estimate stature from human dry sterna (Table 3).

The average female stature observed by various authors ranging from 150.32 cm to 164.40 cm. In the present study the mean stature of female was 156 ± 7 cm which was comparable to the study done by Singh et al[13], Chandrakant et al[14]. The mean stature of female observed by Gupta et al[15] was minimum (150.32 ± 7.2cm) and maximum average stature observed by Saraf et al[16] was 164.4±3.50 cm. The mean of sternal measurements observed in present study was higher than previous researchers except Yonguc et al[17].

Similarly mean combined length of manubrium and mesosternum was found to be more as compared to previous studies except study done by Yonguc et al[17] and Singh et al[13].

Very few authors[13,17,19] had taken xiphisternum length into consideration for calculating total sternal length. The observed mean of total length of sternum in present study was lower than observed by Yonguc et al[17] and Baraw et al[19] (Table 4).

The variability of mean stature and mean combined length of sternum could be multifarious and depends upon genetic factors, nutritional status, and pathological conditions. Recording of anthropometric features of a particular region would be helpful in preparation of data bank for anthropological studies and helpful to know the variations arises due to secular trends in the population.

Table 3. Comparison of study results with present study

Study	Range of Stature cm.	Mean Stature ±SD cm	Sternal parts	Mean ±SD cm	Regression Model	r	R^2	SEE
Singh et al[13] (n=91)	136-177	156 ±6.98	A	4.72 ± 0.51	134.69 + 0.6 x A	0.191	0.141	8.19
			B	7.85 ± 1.023	144.02 + 0.16 x B	0.255	0.05	6.83
			C	14.39 ± 1.24	128.85 + 0.22 x C	0.318	0.1	6.65
Chandrakant et al[14] (n=50)	140-181	155.7 ±8.1	A	4.37 ± 0.42	138.129+ 0.519 x A	0.148	0.144	9.21
			B	7.88 ± 1.43	150.126+ 0.143 x B	0.243	0.055	9.51
			C	12.24 ± 1.62	140.315 + 0.167 x C	0.259	0.103	9.26
Gupta et al[15] (n=34)	140-165	150.32 ±7.20	A	3.72 ±-0.141	30.455 + 32.15 x A	0.631	0.398	5.67
			B	8.16 ± 0.813	143 + 0.868 x B	0.098	0.01	7.28
			C	11.88 ± 0.88	131.62 + 1.574 x C	0.192	0.037	7.181
Saraf et al[16] (n=50)	150-173	164.4±3.50	A	4.3 ± 0.591	147.079 + 0.403 x A	0.68	0.463	2.59
			B	7.813± 1.505	150.815 + 0.174 x B	0.747	0.558	2.35
			C	12.114± 1.78	143.880 + 0.169 x C	0.859	0.738	1.81
Yonguc et al[17] (n=30)	147.068 - 173.332	160.2 ±6.7	A	4.83 ± 0.54	120.276+ 0.827 x A	0.67	0.448	0.173
			B	9.71 ± 0.95	134.845+ 0.261 x B	0.372	0.138	0.123
			C	14.49 ± 1.10	95.139 + 0.449 x C	0.662	0.547	0.077
Khartade et al[18]	137 - 165.2	150.90±5.92	A	4.543 ± 0.665	144.1 + 0.149 x A	0.167	0.028	5.9
			B	8.415 ± 0.861	145.5 + 0.064 x B	0.093	0.008	5.96
			C	12.958 ± 0.924	133.6 + 0.133 x C	0.207	0.043	5.85
Present study	142-170	156±7	A	4.806 ± 0.405	146.108 + 0.207 x A	0.127	0.016	6.645
			B	8.431 ± 0.698	102.947 + 0.63 x B	0.665	0.442	5.003
			C	13.233 ± 0.9	99.83 + 0.42 x C	0.579	0.335	5.464
*** A = Length of Manubrium, *B=Length of body of sternum, *C=Combined length (A+B)**								

Correlation coefficients for total sternal length which includes combined length and length of xiphisternum was found to be higher in present study than Singh et al[13] (r=0.1). Correlation coefficient for TSL observed by Yonguc[17] and Barwa et al[19] was nearly same as the present study (Table 4).

Table 4. Relation of stature and Total length of Sternum reported by various authors

Studies	Mean ±SD	SEE	R	R2	Linear regression equation
Singh et al[13]	143.1± 12.45	6.66	0.317	0.1	130.82 +0.18 x TSL
Yonguc et al[17]	179.2 ± 16.0	0.059	0.662	0.438	110.713 + 0.276 x TSL
Baraw R et al[19]	163 ± 18.0	3.9	0.606	0.368	84.7 + 4.1 x PCL/ TSL
Present Study	157.16±10.63	5.401	0.592	0.35	98.219+0.368 x TSL

When stature and manubrium length was correlated, a moderate correlation (r = >0.5) was observed by Saraf et al Gupta et al and Yonguc et al.[15-17] Present study found a weak correlation (r=0.127) when linear regression analysis done for stature and length of manubrium, suggesting manubrium a less reliable parameter for stature estimation in female. Results of present study were in consonance with the study done by Singh et al, Chandrakant et al and Khartade et al.[13,14,18]

When the stature was correlated with length of mesosternum / length of body and combined length of manubrium and mesosternum of sternum all discussed previous studies except Saraf et al[16] observed a much weaker correlation than present study. Correlation of stature observed by them on these two sternal measurements were slightly stronger than the present study. In the present study, correlation of body of sternum was found to be highest (r=0.665) among the various sternal parameters suggesting its strong association with stature. In previous discussed studies no researcher had mentioned this fact.

Coefficient of determination ($R^{2)}$ predicts the outcome of a regression model. A value of R^2 near to 1 will predicts the stature more accurately. Similarly, a low Standard error of estimation (SEE) in any regression analysis narrows down the variation in regression equation. Comparing the results of present study with previous studies, Saraf et al[16] observed a high coefficient of determination (0.738) for regression model used to estimate stature from combined length of manubrium and mesosternum and Yonguc et al[17] observed a lowest SEE (0.007). The present study agreed that estimation of stature was possible from length of mesosternum which is evident buy its high R^2 (0.442). Rest of the studies were not able to predict the stature based on sternal measurements, more accurately than present study.

V. Conclusion

In present study female stature correlates well with length of mesosternum. Length of manubrium was least predictive of stature. Combined length of manubrium and mesosternum and total sternal length were moderately predictive of female stature. So, the sternum could serve as an important tool for estimation of stature but only in the absence of long bones. On comparing the results of previous studies, it is concluded that, formulae developed for one region may not be applicable for other regions. So, regional studies should be conducted so that specific formulae may be derived for each population and gender.

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