Original Article

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Estimation of stature from the length of sternum

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Abstract

The role of Forensic anthropology to derive alternative and newer modes of identification is increasing every day. Estimation of stature is one of the important initial steps during forensic analysis of human skeletal remains. The aim of the present study was to derive a linear regression formula for estimating stature of adult Indian males from the length of the sternum. The study included 100 male & female sternums of Indian origin dissected from cadavers during medico-legal autopsies. Regression equation derived for both sexes collectively was "Stature=94.228 + 4.474 × (Combined Length of manubrium and body of sternum)", with Standard Error=3.901cm and strength of association=0.858. This preliminary study concludes that the length of the sternum can be used as a tool for stature estimation in adult Indian males.

Keywords: Forensic Anthropology; Stature Estimation; Sternal Length; Linear Regression.

Introduction

For medicolegal studies, examination of human skeleton has obviously an utmost importance for the identification purpose. The experts are always facing a problem in identifying whether skeleton remains are of human being or not as well in estimating correct age, sex and stature of the specimen available. According to krogman, if the entire skeleton is available for examination, sexing of the adult skeleton can be done with 100% both skull and pelvis are accuracy, with the help of skull up to 90%, with the help of pelvis up to 95%, with the help of the long bones up to 80%, and when available then up to 98% [1].

Sternum as an individual parameter for the determination of sex was first studied in 1788 by Wenzel [2]. He described the difference in ratio between the length of manubrium and body of sternum in both sexes. The study opened vast avenues for Feigal (1837) [3], Hyrtl (1788) [4], Dwight (1881) [5]; Strauch (1881) [6] which was followed by Patermollar (1890) [7] and Paterson (1905) [8]. All these workers studied the old parameters of sternum and also tried some new optometric parameters, but could not establish any new parameter.

Stature provides one aspect of an individual's physiognomy, and its determination is one of the important initial steps during forensic analysis of skeleton remains [9]. Stature may be estimated by means of various anthropometric measurement of the skeleton. Such estimation is based on the relations between skeleton elements and stature [10]. It is an established fact that stature bears a direct relation to the length of various bones. The examination of long bones provides the most accurate stature estimation potential. However, long bones may not be present in every instance, necessitating the possible use of other skeleton elements such as sternum when present [11,12,13]. Telkka opined that racial or ethnic group would need different studies to be done over sternum to derive specific result applicable to that particular racial or ethnic group as racial or ethnic variations arise in different geographic regions [14].

The present study is an attempt to study the

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sternum in the purview ofto derive regression formula for the estimation of stature for the both sexes separately and for both sexes collectively.

The result achieved by the existing parameter and those achieved by this study are tabulated and graphically plotted for study. All the measurements and the indices are statistically exercised for the accuracy and reliability for the future use.

Aims and Objectives

1. To derive regression formula for the estimation of stature.
2. To compare the results of this study with other workers

Material and Method

The present study of 100 cases was conducted at mortuary of P.D.U. Hospital and Medical College, Rajkot during the period of 6th January 2010 to 20th August, 2011.

The materials for the present study consist of sternum bones obtained from the cadavers brought for the post-mortem examination at Rajkot after taking necessary consent from the relatives and police.

All autopsies of medico-legal cases of both sexes, having age above 17 years were included in the study.

The cases from both urban and rural areas were included in the study.

The bodies that were decomposed, charred, mutilated and with physical anomalies affecting the study were excluded from the study.

The information about the age of the deceased was obtained from the nearest relatives and investigating officer and was verified by necessary documents. The age of the deceased was rounded off to full figures. Despite of stringent rules on compulsory birth and death registration, there are many cases which do not have a birth certificate today were being excluded from the study.

The dead body was examined externally for various signs of congenital abnormality. History of dietary habits and any hormonal or metabolic disorder was enquired from close relatives of deceased.

The body was placed in supine position on a flat, hard surfaced autopsy table, with the knee and hip joints extended, and the neck and feet in neutral position. The cadaveric length (stature) was measured between the vertex of the head and the heel using a measuring tape.

After removing from cadaver, soft tissues and muscles were removed from the bones as much as possible. The collected sternum bones were tagged and put in a solution of sodium chloride for a week for maceration. These were cleaned and soft tissues were removed and than bones were put in to the solution of hydrogen peroxide for cleaning.

All the required measurements were taken with Baker's Digital Calliper having reading accuracy of 0.01mm/0.0005 inches and with measuring range of 0-300 mm/0-12 inches. A rectangular wooden board was taken; all four borders of the wooden board were thicker than then the rest of the board so that while taking measurements sternum remain in contact with two thicker borders placed at 90 degree with each other . This will confirm the position of the sternum and it will not move while taking the measurement with calliper. The sternum bone taken for measurement was placed on this board in such a way that the posterior surface of the sternum was in contact with the surface of the board. This was further supported with the hand at the xiphoid region during the examination. The sternum placed in such a way was practically immovable during the examination. After proper positioning, following measurements were taken by digital calliper.

1. *Length of Manubrium (M):* It is the distance from suprasternal notch to sternal angle in midline.
2. *Length of Body of Sternum (B):* It is the distance from sternal angle to the junction of body of sternum to xiphoid process in the midline.
3. *Combined Length of Manubrium and Body of Sternum (M+B):* It is the distance from suprasternal notch to junction of body of sternum to xiphoid process in the midline.

The data obtained were analysed statistically to find out the mean and standard deviation for each of the above measurements and indices in both the sexes. The P value was determined to find out whether the sexual difference between means were significant or not. The data was also analysed statistically to find out the number of cases lying in overlapping zones and to find out reliability of each and every parameter separately. The bar diagram of each parameter was plotted taking measurement on X axis and number of cases on Y axis. From bar diagram the overlapping zone, identification point and percentage of cases beyond the identification point were determined for each parameter.

For determining the stature all the above parameters were taken into consideration.The data

were analyzed using statistical programme for social science (SPSS) Version 17 and Microsoft Excel to derive a linear regression equation for stature estimation. To assess the correlation between stature and the length of the sternum, Pearson's correlation coefficient was calculated and its significance was tested by independent t test. P-value of less than 0.05 was considered significant.

Observations and Discussion

Table 1 shows sex wise distribution of stature, which suggests that the maximum number of total cases were in range of 156-160(24%), followed by stature range of 151-155 (21%). Lowest numbers of total cases were found in range of 135-140 (1%).

Highest numbers of male cases were found in stature range of 156-160 (18%) while highest numbers of female cases were found in range of 146-150 (9%).

Table 2 shows descriptive statistics of study sample .Mean age and mean stature of male were higher than female. Mean values of all the parameters in male were higher than female except for two parameters i.e. sterna index and width index.

Table 3 shows that Correlation coefficient of stature of both male and female subjects collectively with all the parameters were obtained and it was found significantfor all the parameters ($P<0.05$) except for width index ($P=0.131$).

The correlation coefficient indicates the strength of association between stature and various parameters used in present study and it varies from -1 (negative correlation) to +1 (positive correlation) [53].

In the present study, correlation coefficient for combined length of manubrium and body of sternum (L1+L2) (0.858) was found higher than other parameters which suggested combined length had maximum strength of association with stature.

Table 4 shows that Correlation coefficient of stature of male subjects with all the parameters were obtained and it was found significant for length of manubrium (L1), length of body of sternum (L2), combined length of manubrium and body of sternum (L1+L2) and width of manubrium (W) ($p<0.05$).

In the present study, it was observed that correlation coefficient for combined length of manubrium and body of sternum (L1+L2) (0.650) was found higher than length of manubrium (L1) (0.408), length of body of sternum (L2) (0.612) and width of manubrium (0.271) which suggested combined length had maximum strength of association withstature.

Table 5 shows that Correlation coefficient of stature of female subjects with all the parameters were

Table 1: Sex wise distribution of the stature

Stature (In cm.)	Male (%)	Female (%)	Total (%)
135-140	00(0%)	01(1%)	01(1%)
141-145	00(0%)	04(4%)	04(4%)
146-150	02(2%)	**09(9%)**	11(11%)
151-155	13(13%)	08(8%)	21(21%)
156-160	**18(18%)**	06(6%)	**24(24%)**
161-165	16(16%)	01(1%)	17(17%)
166-170	16(16%)	00(0%)	16(16%)
171-175	06(6%)	00(0%)	06(6%)
TOTAL	**71(71%)**	**29(29%)**	**100(100%)**

Table 2: Descriptive statistics of the study sample

Parameter	Male			Female		
	Min.	Max.	Mean	Min.	Max.	Mean
Age(years)	17	80	37.94±17.47	17	70	32.37±14.67
Stature(cm.)	150	173	161.35±6.30	135	164	151±6.35
Length of Manubrium(L1)	40.55	66.87	48.60±4.97	27.04	56.72	44.41±5.89
Length of Body of Sternum(L2)	74.57	111.58	93.63±8.35	61.05	84.49	74.30±7.16
Combined length(L1+L2)	126.27	159.40	142.24±8.95	100.31	135.85	118.71±10.44
Width of manubrium(W)	42.95	66.17	54.24±5.23	41.49	64.15	50.73±7.08
Width of first sternebra(W1)	18.92	36.10	26.68±3.63	16.63	39.42	23.58±4.92
Width of third sternebra(W3)	22.37	50.55	31.91±4.84	21.29	37.25	26.98±4.16
Sternal Index	39.33	73.51	52.39±7.70	36.70	80.17	60.12±8.63
Width Index	57.151	110.94	84.63±12.60	61.94	121.51	87.46±11.62

Table 3: Level of significance of differentmeasurements for both sexes

	L1	L2	L1+L2	W	W1	W3	Sternal Index	Width Index
Pearson Correlation Coefficient	0.451	0.815	**0.858**	0.300	0.236	0.359	-0.366	-0.152
P value	0.000	0.000	0.000	0.002	0.018	0.000	0.000	0.131

Table 4: Level of significance of different measurements for male subjects

	L1	L2	L1+L2	W	W1	W3	Sternal Index	Width Index
Pearson Correlation Coefficient	0.287	0.720	0.832	0.271	0.067	0.150	-0.221	-0.132
P value	0.015	0.000	0.000	0.022	0.576	0.212	0.063	0.272

Table 5: Level of significance of different measurements for female subjects

	L1	L2	L1+L2	W	W1	W3	Sternal Index	Width Index
Pearson Correlation Coefficient	0.408	0.612	**0.650**	0.023	0.018	0.093	-0.050	-0.054
P value	**0.028**	**0.000**	**0.000**	0.904	0.927	0.632	0.798	0.780

Table 6: Multilinear regression equation for estimating stature

Sex	Equation	SE(cm.)	R
Both sex	S=94.228+(4.474)×CL	3.901	0.858
Male	S=78.027+(0.586)×CL	6.706	0.832
Female	S=104.07+(0.395)×CL	10.612	0.650

*S= Stature, *SE= Standard Error, *R=Strength Of Association
*CL= Combined Length Of Manubrium And Body of sternum (L1+L2)

obtained and it was found significant for length of manubrium (L1), length of body of sternum (L2) and combined length of manubrium and body of sternum (L1+L2) ($p<0.05$).

In the present study, it was observed that correlation coefficient for combined length of manubrium and body of sternum (L1+L2) (0.650) was found higher than length of manubrium (L1) (0.408) and length of body of sternum (L2) (0.612) which suggested combined length had maximum strength of association with stature.

Table 6 shows that The multilinear regression was applied for all the subjects collectively as well as for male and female subjects separately considering all the parameters in statistical programme for social science (SPSS) Version 17 and Microsoft Excel. On applying multilinear regression with backward method maximum association of stature was found with combined length out of all significant parameters. Regression equation for both sexes collectively as well as for both sexes separately was obtained.

Maximum strength of association of equation with the stature was found for both sexes (0.858) followed by for male (0.832) and for female (0.650).

Summary and Conclusion

- Regression equation derived for both sexes collectively was "Stature=94.228 + 4.474 × (Combined Length of manubrium and body of sternum)", with Standard Error=3.901cm and strength of association=0.858.
- Regression equation derived for male sex was "Stature=78.027 + (0.586) × (combined length of manubrium and body of sternum)", with Standard Error=6.706cm and strength of association=0.832.
- Regression equation derived for female sex was "Stature=104.07 + (0.395) × (Combined Length of manubrium and body of sternum)", with

Standard Error=10.612cm and strength of association=0.650.

It is also evident from above findings that out of all the parameters used in the study for estimation of stature, combined length of manubrium and body of sternum is most reliable.

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