

Reliability of Sternal Index in Determination of Sex in Rajkot Region: A Prospective Study

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Abstract

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. Sternum as an individual parameter for the determination of sex was first studied in 1788 by Wenzel. Sternal index, also known as manubrio-corpus index is an important and frequently studied parameter from this point of view. The present study is an attempt to know the reliability of sternal index in the differentiation of sex. The 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 study consist of sternum bones obtained from the cadavers brought for the post-mortem examination, after taking necessary consent from the relatives and police. Mean *sternal index* in males was 52.39 mm with SD of 7.70 while that of female cases was 60.12 mm with SD of 8.63. Sternal index in both sex had overlapping zone in the range of 39.33-73.51 mm. Observations of all male cases were falling in this range while 6.90% of female cases were falling outside this range.

Keywords: Identification; Sternum; Sternal Index.

Introduction

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 Paternollar (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 [11-13]. Telkka opined that racial or ethnic group would need different studies to be done over sternum to derive specific result applicable to that

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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 sternum in the purview of existing parameter for sex. 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.

Material and Methods

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.

For the present study of 100 cases, Sternum bones obtained from the cadavers brought for the post-mortem examination at Rajkot after taking necessary consent from the relatives and police. The bodies that were decomposed, charred, mutilated and with physical anomalies affecting the study were excluded from the study.

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 external examination, all three body cavities were opened by routine skin incisions. The skin and subcutaneous tissues were reflected from the chest and neck. The sternum was removed by cutting costal cartilages just medial to costo-chondral junction and reflected from xiphisternum end to the manubrium sterni and by excising the sterno-clavicular joint.

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.

For determining the sex; 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.

Length of Manubrium (L1)

It is the distance from suprasternal notch to sternal angle in midline.

Length of Body of Sternum (L2)

It is the distance from sternal angle to the junction of body of sternum to xiphoid process in the midline.

Manubrio corpus index (Sternal index) = $L1/L2 \times 100$

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.

Results

Table 1 shows sex wise distribution of length of manubrium (L1) which suggests that maximum number of cases were falling in the range of 46-50.99 mm. in both sexes i.e. 31% in male and 12% in female.

Total number of cases falling in the range of 41-55.99 mm were 65 i.e. 91.54% of total number of male cases, while in female total number of cases falling in the range between 36-50.99 mm were 25 i.e. 86.20% of total number of female cases.

Minimum length of manubrium found in male was 40.55 mm and in female it was 27.04 mm. Maximum length of manubrium found in male was 66.87 mm

and in female it was 56.72.

Overall mean of total cases (i.e.100 cases) was 47.39 and SD \pm 5.56.

Mean of male cases was 48.60 and SD \pm 4.97.

Mean of female cases was 44.41 and SD \pm 5.89.

Average difference in mean of male and female cases was 4.19. By applying independent t-test it was observed that difference found in mean of male and female was statistically significant as the P value obtained was 0.000. (P value was taken significant at the level $P < 0.05$).

Distributions of male and female cases were analyzed for overlapping. Overlapping zone is 40.55-56.72 mm. Number of male cases falling in the overlapping zone was 67 i.e. 94.36% of total number of male cases. Number of female cases which were falling into overlapping zone was 23 i.e. 79.31% of total number of female cases. It was found that all the sternum bones having length of manubrium > 56.72 mm were of males and length < 40.55 mm were of females, so by this only 5.64% of male cases and 20.69% of female cases sex could be determined correctly.

Table 2 shows sex wise distribution of length of body of sternum (L2) which suggests that maximum number of cases in males were falling in the range of 86-90.99 mm. i.e. 18% of total cases and in females maximum number of cases were falling in the range

of 71-75.99 mm i.e. 8% of total cases.

Minimum length of body of sternum found in male was 74.57 mm and in female it was 61.05 mm. Maximum length of body of sternum found in male was 111.58 mm and in female it was 84.49.

Overall mean of total cases (i.e.100 cases) was 88.02 and SD \pm 11.90.

Mean of male cases was 93.63 and SD \pm 8.35.

Mean of female cases was 74.30 and SD \pm 7.16.

Average difference in mean of male and female cases was 19.33. By applying independent t-test it was observed that difference found in mean of male and female was statistically highly significant as the P value obtained was 0.000. (P value was taken significant at the level $P < 0.05$).

Distributions of male and female cases were analyzed for overlapping. Overlapping zone was 74.57-84.49 mm. Number of male cases falling in the overlapping zone was 10 i.e. 14.08% of total number of male cases. Number of female cases which were falling into overlapping zone was 13 i.e. 44.82% of total number of female cases. It was found that all the sternum bones having length of body of sternum > 84.49 mm were of males and length < 74.57 mm were of females, so by this 85.92% of male cases and 55.18% of female cases sex could be determined correctly.

Table 1: Sex wise distribution of length of manubrium (l1)

Length of Manubrium (In mm.) (L1) IN MM.	No. of Cases Male (%)	No. of Cases Female (%)
25-30.99	00(0%)	01(1%)
31-35.99	00(0%)	01(1%)
36-40.99	02(2%)	05(5%)
41-45.99	22(22%)	08(8%)
46-50.99	31(31%)	12(12%)
51-55.99	12(12%)	01(1%)
56-60.99	03(3%)	01(1%)
61-65.99	00(0%)	00(0%)
66-70.99	01(1%)	00(0%)
TOTAL	71(71%)	29(29%)

Table 2: Sex wise distribution of length of body of sternum (l2)

Length of Body of Sternum (L2) In Mm.	No. of Cases Male (%)	No. of Cases Female (%)
61-65.99	00(0%)	04(4%)
66-70.99	00(0%)	04(4%)
71-75.99	01(1%)	08(8%)
76-80.99	02(2%)	06(6%)
81-85.99	10(10%)	07(7%)
86-90.99	18(18%)	00(0%)
91-95.99	15(15%)	00(0%)
96-100.99	09(9%)	00(0%)
101-105.99	07(7%)	00(0%)
106-110.99	08(8%)	00(0%)
111-115	01(1%)	00(0%)
TOTAL	71(%)	29(%)

Table 3 shows sex wise distribution of sternal index which suggests that maximum number of cases in males were falling in the range of 46-50.99mm. i.e. 25 % of total number of cases and in females maximum number of cases were falling in the range of 61-65.99 mm i.e. 8% of total number of cases.

Minimum sternal index found in male was 39.33 mm and in female it was 36.70 mm. Maximum sternal indexes found in male was 73.514 mm and in female it was 80.1718 mm.

Overall mean of total cases (i.e.100 cases) was 56.64 mm and SD \pm 8.68.

Mean of male cases was 52.39 mm and SD \pm 7.70.

Mean of female cases was 60.12 mm and SD \pm 8.63.

Average difference in mean of male and female cases was 7.73 mm. By applying independent t-test it was observed that difference found in mean of male and female was statistically significant as the P value obtained was 0.000. (P value was taken significant at the level $P < 0.05$).

Distributions of male and female cases were analyzed for overlapping. Overlapping zone was 39.33-73.51 mm. Number of male cases falling in the overlapping zone was 71 that are 100 % of total number of male cases. Number of female cases which were falling into overlapping zone was 27 that is 93.10% of total number of female cases. Male sex could not be determined with this criterion and only in 6.9% cases of female sex could be determined correctly.

Table 3: Sex wise distribution of sternal index (L1/L2 \times 100)

Width of Third Sternal Index (L1/L2 \times 100) In Mm.	No. of Cases Male (%)	No. of Cases Female (%)
35-40.99	04(4%)	01(1%)
41-45.99	08(8%)	00(0%)
46-50.99	25(25%)	03(3%)
51-55.99	13(13%)	04(4%)
56-60.99	11(11%)	07(7%)
61-65.99	07(7%)	08(8%)
66-70.99	01(1%)	04(4%)
71-75.99	02(2%)	01(1%)
76-80.99	00(0%)	01(1%)
TOTAL	71(71%)	29(29%)

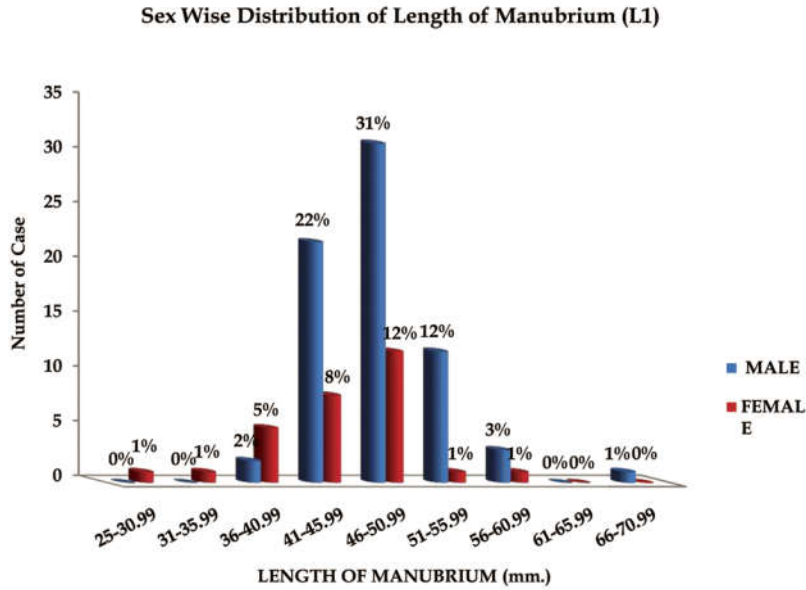
Table 4: Comparison of cases according to sex wise distribution of sternal index

Sternal Index	Tailor et al. ¹⁵		Present Study	
	Male (%)	Female (%)	Male (%)	Female (%)
36-40	01(0.86%)	02(1.72%)	04(4%)	01(1%)
41-44	02(1.72%)	00(0%)	07(7%)	00(0%)
45-48	11(9.48%)	02(1.72%)	14(14%)	03(3%)
49-52	17(14.65%)	07(6.03%)	16(16%)	00(0%)
53-56	20(17.24%)	03(2.58%)	10(10%)	06(6%)
57-60	07(6.03%)	15(12.93%)	10(10%)	05(5%)
61-64	07(6.03%)	03(2.58%)	05(5%)	04(4%)
65-69	05(4.31%)	06(5.17%)	02(2%)	08(8%)
70-73	03(2.58%)	01(0.865)	03(3%)	01(1%)
74-77	02(1.72%)	01(0.865)	00(0%)	00(0%)
78-81	01(0.86%)	00(0%)	00(0%)	01(1%)
TOTAL	76	40	71	29

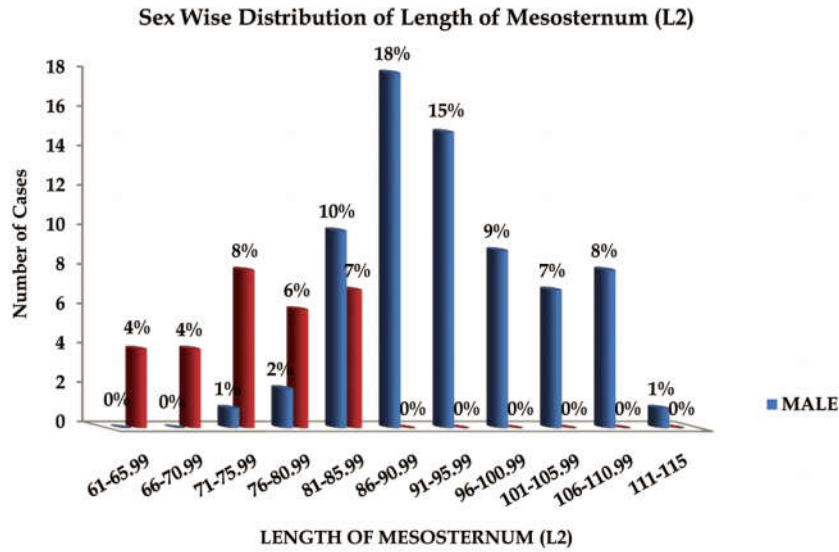
Table 5: Ability of Hyrtl's⁴ law (sternal index if < 50 =male, if > 50 =female) as recorded by various workers

Observer	Year	Number of Specimen	Sex	% Obeying Law
Dwight ¹⁶	1890	142	M	59.10
		86	F	60.40
Patermoller ⁸	1890	55	M	65.00
		33	F	-
Krause ¹⁷	1897	-	M	-
		14	F	43
Ashley	1956	85	M	64.70
African ^{18,19}		13	F	69.20
Ashley European ^{18,19}	1956	378	M	52.90
		171	F	69.30
Narayan and Varma ²⁰	1958	126	M	34.12
		27	F	81.48
JIT et al. ²¹	1980	312	M	31.08
		88	F	88.64
Dahiphale et al. ²²	2000	96	M	52.20
		47	F	100
Present Study	2011	71	M	54.92
		29	F	86.20

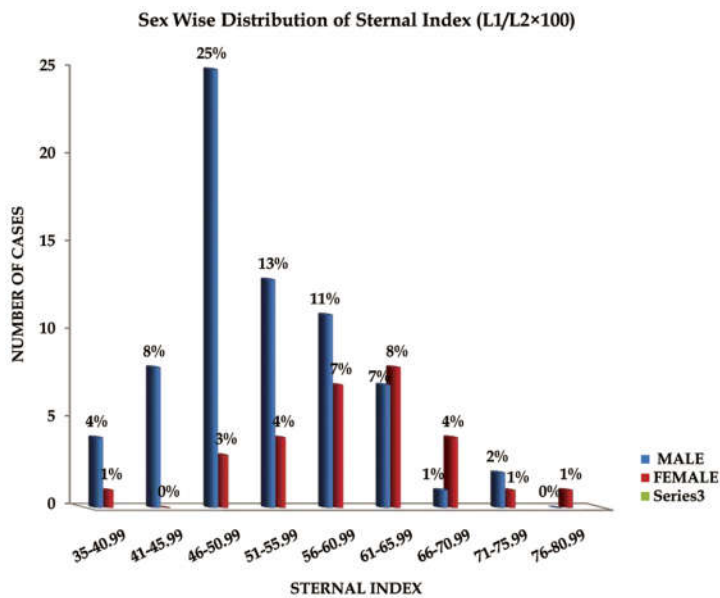
Dig. 1:



Dig. 2:



Dig. 3:



Discussion

Observations of sex wise distribution of sterna index of present study were compared with the study of Tailor et al. (2008) [15].

In present study maximum numbers of male cases (16%) were falling in the range of 49-52 mm. while in study of Tailor et al. [15] maximum numbers of male cases (17.24%) were falling in the range of 53-56 mm. In present study maximum number of female cases (8%) were falling in the range of 65-69 mm. while in study of Tailor et al. [15] maximum number of female cases (12.93%) were falling in the range of 57-60 mm.

In present study mean of male cases was 52.39 mm and SD \pm 7.70 which was 57.42 mm and SD \pm 8.41 in the study of Tailor et al. [15] In present study mean of female cases was 60.12 mm and SD \pm 8.63 which was 59.12 mm and SD \pm 8.0 in study of Tailor et al [15].

In present study difference in mean of male and female cases was found significant ($p < 0.05$) while it was found insignificant in study of Tailor et al [15].

According to Wenzel (1788) [2] the manubrium in the two sexes, is almost equal in length, but the body of sternum is proportionally longer in males than the females. This led to enunciation of Hyrtl's law [4], according to which manubrio corpus index (sternal index) exceeds 50 in females and is less than 50 in males. Table.16 gives the percentage of cases obeying the law in the two sexes. In present study percentage of male cases obeying the law (54.92%) was comparable to the study of Dwight [21] (59.10%), Ashley in European [22,23] 52.90%), and Dahiphale et al. [30] (52.20%). Percentage of female cases of the present study obeying the law (86.20%) was comparable to the study of Narayan and Varma [55] (81.48%) and Jit et al. [25] (88.64%).

Conclusion

- Mean length of manubrium in males was 48.60 mm with SD of 4.97 while that of females was 44.41 mm with SD of 5.89. Length of manubrium in both sex had overlapping zone in the range of 40.55-56.72 mm. Only 5.64% of male cases had length > 56.72 mm while 20.69% of female had length < 40.55 mm.
- Mean length of body of sternum in males was 93.63 mm with SD of 8.35 while that of females was 74.30 mm with SD of 7.16. Length of body of sternum in both sex had overlapping zone in

the range of 74.57-84.49 mm. 85.92% of males had length > 84.49 mm while 55.18% of female had length < 74.57 mm.

- Mean sternal index in males was 52.39 mm with SD of 7.70 while that of female cases was 60.12 mm with SD of 8.63.

Sternal index in both sex had overlapping zone in the range of 39.33-73.51 mm. Observations of all male cases were falling in this range while 6.90% of female cases were falling outside this range.

So Male sex could not be determined with this criterion and only in 6.9% cases of female sex could be determined correctly.

The variations in the sternal index are on account of different geography, ethnic and racial distribution. Further elaborative morphometric studies are required to make sternal index a valuable parameter in sexual dimorphism.

A number of workers have applied Hyrtl's law in their studies to find out its reliability in sexual dimorphism from sternum. In the present study 54.92% of male and 86.20% of female sterna were found obeying this law.

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