Original Article

Determination of sex from the width and the area of human sternum & manubrium in Gujarat population

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ABSTRACT

Background: Determination of sex from the skeletal remains is of immense importance in the field of forensic medicine, physical anthropometry and anthropology. Various previous studies have demonstrated sternum as an important tool for the determination of sex.

Aims: Aim of the present study was to establish normal range of values for the width and the area of sternum in the studied population and evaluate the sexual dimorphism in the sternum.

Material & Methods: The present study was conducted at M.P. Shah Govt. Medical College, Jamnagar on Computed tomography scans of a total of 83 adult Gujarati individuals (57 males, 26 females). The sternal width and the sternal area were measured and analysed.

Results: The width of the sternum at 1st and 3rd sternebrae and sternal area were found to be larger in male and the difference was statistically significant. The sternal area was found to be the most accurate for determination of sex among all studied parameters, which accurately identified 59.63% of sterna as male and 30.77% as female by the method of identification point.

Conclusion: The sternal area is the most reliable criteria for the determination of the sex of a sternum. The widths of the sternum were found to be non-accurate for the determination of sex of a sternum. The sternum of the female is on average narrower and smaller than the male sternum.

Key words: Sex determination, sternum, CT scan, Gujarati, sternal area

INTRODUCTION

The gender determination from the skeletal remains is of very much interest in the field of forensic medicine. To identify the sex of the specimen found, with great accuracy and precision, is of utmost importance. The bones are more resistant to the putrification process that makes it important to study, which in turn helps identify the gender determination criteria. Next to pelvis, human skull is regarded as the most accurate indicator of the sex [1]. But when these bones are missing, recent findings have suggested that sternum and manubrium can act as valuable specimens [1, 3-7, 9-19].

Manubriosternum is a flat bone that takes part in the formation of the thoracic cage. It is made up of cancellous bone, which, throughout the life, is filled with haemopoietic bone marrow. The manubrium is attached to the body of the sternum at its lower border by the symphysis type of joint, while its upper margin, known as jugular notch, is concave and free. On sides, manubrium contains facets for the articulation of first and half of the second rib. The body of sternum is attached to the manubrium at upper margin while to the xiphoid process by the lower margin. On the lateral margins it contains facets for the articulation of second to sixth/seventh ribs.

The total length of sternum is approximately 17 cm in males and less in females. The ratio between manubrial and mesosternal lengths differs between the sexes [2]. Wenzel [3] was the first to study the sternum for sexual dimorphism. Ashley [4] extensively presented that the sternum is an index of age, sex and height of an individual and its measurements have an influence on the sex and age of that individual in European and African population. Dwight [5] suggested that the male sternum is considerably longer than the female sternum. He also confirmed that the combined length of manubrium and mesosternum, and the total sternal length provide useful guide to the height of an individual. Similarly, Macaluso [1], Osunwoke [6], Selthofer [7], Torwalt [8], Vella [9], Fernadoz [10], etc., studied the sex differentiation in human sternum by studying its various morphometric measurements in various populations.

In India, various researchers have presented their work on the sternum regarding sex determination. i.e. Singh et al [11,12], Dahiphale et al [13], Gautam et al [14], Puttabanthi et al [15], Kaneriya et al [16], Adhvaryu et al [17], and Mahajan et al [18].

The aim of the present study was to evaluate and establish the normal values and the sex related differences for the sternum using its width and area, in the Gujarati population.

MATERIAL AND METHODS

The present study was conducted on the total of 83 (57 males, 26 females) subjects. The observations were collected from the Department of Radio-diagnosis, M.P. Shah Government Medical College, Jamnagar, Gujarat. The patients who had undergone computed tomography (CT) scan for the conditions other than involvement of sternum were taken in to consideration for the present study. No person was made to undergo a CT scan for the sole purpose of this study.

Subjects aged 18 years and above were included in this study. Subjects with chest trauma, congenital sternal malformation or other anatomical variations were excluded.

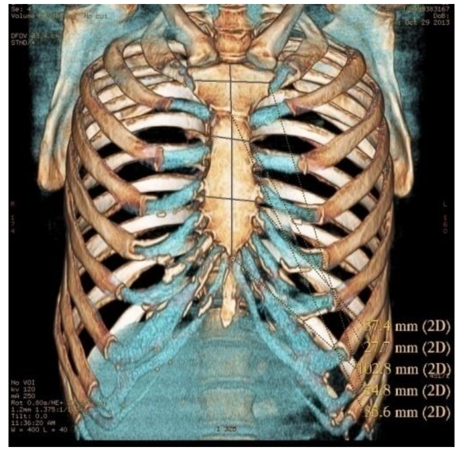
For the morphometry of the sternum, following measurements were taken in to consideration (fig -1):

LENGTH OF MANUBRIUM (ML): It was measured from the centre of suprasternal notch to the centre of the manubrio-sternal junction in mid sagittal plane.

LENGTH OF MESOSTERNUM (SL): It was measured from the centre of manubrio-sternal junction to the centre of sterno-xiphoid junction in the mid sagittal plane.

WIDTH OF MANUBRIUM (MW): It was the distance between the midpoints of the facets for the first costal cartilage on both sides of the bone.

Figure 1: CT scan image depicting linear measurements of sternum



WIDTH OF THE STERNUM AT FIRST STERNEBRA (SW1): It was the distance at the level of line passing from the midpoint between the facet for the second and third costal cartilages on both sides of the bone.

WIDTH OF THE STERNUM AT THIRD STERNEBRA (SW3): It was the distance at the level of line passing from the midpoint between the facet for the fourth and fifth costal cartilages on both sides of the bone.

The above mentioned measurements were further used to calculate various sternal dimensions and indices according to the techniques described by Ashley [4] and McCormick [19].

STERNAL AREA (SA): It is calculated by multiplying the sum of ML and SL with the sum of MW, SW1 and SW3 divided by 3. [(ML+SL) x (MW+SW1+SW3) / 3]

The observations for the width and the area of the sternum were tabulated and the mean, standard deviation, coefficient of variation, standard error of mean, range, identification point and demarking points were calculated for each variable.

The identification point:
The identification points were constituted by the lowest value of a variable in males and highest value for the same in females. All the values less than the minimum value for the males were treated as female bone and the bones having values more than maximum value of females were treated as male bones.

The area between these two values is known as overlapping zone. Variable having a broader overlapping zone is thought to be a bad estimator.

The demarking point:
The demarking point was calculated by using ±3SD in mean. Mean±3SD ensured that 99% of the value fall within the range calculated. The minimum value in males was taken as demarking point for female i.e. the value less than this point falls in female category.

These data were tabulated and then analysed using the IBM SPSS Statistic 20 software package.

The data taken were tabulated and calculated for to find the range of observations, mean, standard deviation, standard error of mean, 95% confidence interval of the difference of mean, Identification and demarking point and overlapping zone.

RESULTS

A total of 83 sterna were measured in the present study. Various measurements, statistical analysis of these measurements, and the indices are shown in Table 1.

Sternal width at the level of 1st and 3rd sternebrae and the sternal area were found to be significantly higher in males than females.

Identification point, overlapping zone, and demarking point showed significant difference between males and females. Table 2 and Table 3 show identification points, IP%, overlapping zone, % of the bones falling in the overlapping zone, demarking point and DP% in both sexes.

For males, sternal area was found to be most accurate criterion to identify sex by the method of identification point. By using this criterion, 59.64% specimens were correctly identified as male, whereas 17.54% specimens were correctly identified by using the sternal width. Overall, 40.35% specimens were falling in the overlapping zone for the sternal area, which is suggestive of the higher accuracy of the criteria for the determination of sex.

By the method of demarking point also the sternal area was found to be most accurate criteria to identify sex. Overall, 43.86% specimens were correctly classified as male by this criterion. Sternal width at the level of 1st and 3rd sternebrae were found to classify 5.26% and 1.75% specimens correctly as male respectively.

The sternal area was found to be most accurate criterion which correctly identified 30.77% specimens as female by the method of identification point. The second most accurate criterion for the same method was the Sternal width at the level of 3rd sternebrae which correctly classified 19.23% specimens as female. Sternal width at the level of 1st sternebrae could identify 11.54% specimen as female by the same method; thus, it was proved to be least accurate criterion.

Sternal area and sternal width at the level of 3rd sternebrae was found to be most accurate criterion by the method of demarking point. It could correctly identify 3.85% specimen as female. Sternal width at the level of 1st sternebrae could not identify any specimen as female so thus it proved to be the least accurate criterion for the determination of sex.

DISCUSSION

The present study evaluated sternal width and sternal area in order to establish the normal values and the sex related differences for the sternum in the Gujarati population. The findings suggest that osteometric evaluation of the sternum can be an effective method for identification of sex in the Gujarati population.

In the present study, the both the width considered of sternum were comparable to the findings by Dahiphaleet al [13], and Singh et al [11, 12]. However, the data were different to those presented by other workers. The sternum area was different from those presented by Macaluso et al (SA [20]&Spain [1]). The differences in findings could be contributed to the regional differences. The comparison of findings by various researchers is presented in table – 4 and 5 below.

In the present study, the most reliable method for sex determination was the sternal area using demarking point or identification point methods. Of all criteria evaluated, maximum specimens were correctly identified through the sternal area. The results from the study can assert the effectiveness of sternum for identification of sex from human remains. The findings from the present study are consistent with previously reported data from various researchers [1,7, 10,11,13,15, 20-23] (as summarized in a table-4& 5).

Table 1: Statistical analysis of various sternal measurements (Males- 57; Females- 26)

Variable	Sex	N	Mean±SD	Standard error of mean (mm)	Mean difference (mm)	P-value*	95% CI	
							Lower	Upper
SW1	Male	57	27.80±3.71	0.4914	4.04	0.0001	2.317	5.749
	Female	26	23.76±3.56	0.6990				
SW3	Male	57	32.25±5.59	0.7408	4.75	0.001	2.095	7.413
	Female	26	27.50±5.59	1.0959				
SA	Male	57	5375.98±766.61(mm^2)	101.5396(mm^2)	1452.29(mm^2)	0.0001	1157.96	1746.60
	Female	26	3923.69±545.01(mm^2)	106.8851(mm^2)				

* p-value was measured by t-test & values <0.01=statistically significant, <0.0001=statistically highly significant

Table 2: range, number and percentage of the sterna falling in overlapping zone and beyond identification point and demarking point for the female sterna

	SW1	SW3	SA
Identification point (IP)	19.3	23.1	3679.16
No. Of the sterna falling below IP	3	5	8
IP%	11.5385	19.23	30.7692
Overlapping zone	19.3 – 30.8	23.1 – 38.6	3679.16 – 5080.07
No. Of the sterna falling in overlapping zone	23	21	18
% of sterna in overlapping zone	88.4615	80.77	69.23
Actual range	17.1 – 30.8	14 – 38.6	3030.72 – 5080.07
Mean±3SD	13.08 – 34.44	10.73 – 44.27	2288.66 – 5558.72
Demarking point (DP)	16.67	15.48	3076.15
No. Of the sterna falling beyond DP	0	1	1
DP%	0	3.846	3.846

Table 3: range, number and percentage of the sterna falling in overlapping zone and beyond identification point and demarking point for the male sterna

	SW1	SW3	SA
Identification point (IP)	30.8	38.6	5080.07
No. Of the sterna falling beyond IP	10	10	34
IP%	17.544	17.544	59.64912
Overlapping zone	19.3 – 30.8	23.1 – 38.6	3679.16 – 5080.07
No. Of the sterna falling in overlapping zone	47	47	23
% of sterna in overlapping zone	82.456	82.456	40.35
Actual range	19.3 – 39.4	23.1 – 45.5	3679.16 – 7118.72
Mean±3SD	16.67 – 38.93	15.48 – 49.02	3076.15 – 7675.81
Demarking point (DP)	34.44	44.27	5558.72
No. Of the sterna falling beyond DP	3	1	25
DP%	5.2632	1.7544	43.85965

It was found in the present study that the sternal width at 1st and 3rd sternebrae are inaccurate criteria to determine the sex of a sternum of unknown sex. The difference found between males and females was statistically significant but the number of the subjects falling in the overlapping zone was high which shows decreased accuracy of the parameter to assess the sex of the bone correctly.

Table 4: showing the comparison of the findings of the present study with the same of the other researcher for sternal width at the 1st and 3rd sternebrae

RESEARCHER	SEX (No)	SW1±SD (mm)	SW3±SD (mm)
Dahiphale (Maharashtra)	M (96)	27.17±3.89	31.95±5.77
	F (47)	24.44±4.13	28.24±4.72
Singh J (North India)	M (252)	27.03±3.58	33.53±5.49
	F (91)	23.11±2.85	28.01±4.84
Puttabanthi S. (Andhra Pradesh)	M (57)	53.32±13.50	33.41±6.72
	F (22)	27.73±7.12	30.64±5.7
Jit et al (chandigarh)	M (312)	27.45±3.72	32.58±5.80
	F (88)	24.32±3.94	29.19±5.55
Fernandez (spain)	M(43)	26.67±3.78	32.81±5.18
	F(40)	23.54±3.17	30.29±4.95
Atal et al (delhi)	M(50)	25.88±2.01	28.52±2.64
	F(50)	21.93±1.64	24.66±1.95
Ramadan et al (Turkey)	M(123)	28.7±3.8	24.95
	F(83)	25.2±3.3	21.83
Macaluso (south Africa)	M(197)	34.9±5.9	31.77
	F(143)	30.7±5.1	27.30
Macaluso PJ (Spain)	M (65)	28.31±3.28	35.36±5
	F (51)	24.68± 4.43	30.15± 5.51
Present study (Saurashtra region)	M (57)	27.8±3.71	32.25±5.59
	F (26)	23.77±3.56	27.5± 5.59

Table 5: showing the comparison of the findings of the present study with the same of the other researcher for sternal area

RESEARCHER	SEX (No)	SA±SD (mm^2)
Macaluso PJ (Spain)	M (65)	6506.42±703.29
	F (51)	4752.66±687.95
Selthofer (Croatia)	M(55)	6386±768
	F(35)	5026±745
Present study (Saurashtra region)	M (57)	5375.98±766.61
	F (26)	3923.69±545.01

The width of the sternum of the Gujarati population was found to be smaller than the sternum of the South African and Spanish population. Among the other region of India, the sternum of the Gujarati population was comparable with the same of the sternum from the Marathi and Punjabi population. The Gujarati sternum was found to be narrower than the sternum from the population of Andhra Pradesh while it was found to be broader than the sternum of the population of Delhi.

The observations found in the present study were suggesting comparable width at the level of 1st sternebrae with the sternum of the Turkish population, but the width at the level of 3rd sternebrae was found to be wider in the present study suggesting the broad lower portion of sternum in Gujarati population.

The surface area of the sternum of the Gujarati population was found to be smaller than those from the Spanish and Croatian population.

CONCLUSION

The result and comparative observation in the present study show that the sternal area is the most reliable criteria for the determination of the sex of a sternum. The widths of the sternum, were found to be non-accurate for the determination of sex of a sternum. Results of the present study shows that absolute values of the measured parameters are significantly different. The sternum of the female is on average narrower and smaller than the male sternum. The mean values of the dimensions of the sternum established in the present study should be kept in mind while dealing with the Gujarati population in various fields as forensic medicine, anthropology, anthropometry, orthopaedics and Radio diagnosis.

Finally, given the relatively small size of the study sample, it is further recommended that additional investigations be conducted on other documented Gujarati population samples to confirm the findings of the present research.

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