Determination of sex from the width and the area of human sternum & manubrium in Gujarati 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 anthropology 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].

Manubriotosternum 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.

**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 results from the specimen as female. The sternal width at the level of 3\textsuperscript{rd} sternebrae 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 3\textsuperscript{rd} sternebrae which correctly classified 19.23\% specimens as female. Sternal width at the level of 1\textsuperscript{st} 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 3\textsuperscript{rd} 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 1\textsuperscript{st} 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)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sex</th>
<th>N</th>
<th>Mean±SD</th>
<th>Standard error of mean (mm)</th>
<th>Mean difference (mm)</th>
<th>P-value*</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1</td>
<td>Male</td>
<td>57</td>
<td>27.80±3.71</td>
<td>0.4914</td>
<td>4.04</td>
<td>0.0001</td>
<td>2.317</td>
<td>5.749</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>26</td>
<td>23.76±3.56</td>
<td>0.6990</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SW3</td>
<td>Male</td>
<td>57</td>
<td>32.25±5.59</td>
<td>0.7408</td>
<td>4.75</td>
<td>0.001</td>
<td>2.095</td>
<td>7.413</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>26</td>
<td>27.50±5.59</td>
<td>1.0959</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA</td>
<td>Male</td>
<td>57</td>
<td>3575.98±766.61(mm²)</td>
<td>101.5396(mm²)</td>
<td>1452.29(mm²)</td>
<td>0.0001</td>
<td>1157.96</td>
<td>1746.60</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>26</td>
<td>3923.69±545.01(mm²)</td>
<td>106.8851(mm²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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

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

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

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

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.
The width of the sternum of the Gujarati population was found to be smaller than those 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 sternbrae with the sternum of the Turkish population, but the width at the level of 3rd sternbrae 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.

REFERENCES


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