



## Original Article

# Sexing of unknown adult human sterna by metrical analysis

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## ABSTRACT

**Introduction:** Examination of bones is important for identification of deceased and estimation of sex. **Aim:** The present study was undertaken to determine sex of unknown adult human sterna by applying Statistical analysis. **Method:** Materials for the study consisted of 79 sterna of unknown sex that were obtained from different Medical institutions in Andhra Pradesh, India. As the bones are of unknown sex FISHERS Z STATISTIC analysis was applied to assume sex. For that the mean, standard deviation, t-value and p-value were calculated. **Result:** Combined mean length of manubrium and mesosternum acts as a best discriminator to sex unknown sterna. Width of first sternebra can discriminate males. Relative width index is also useful to differentiate sex of unknown sterna. Length of Manubrium may act as a good discriminator of female sterna. Remaining parameters like length of mesosternum, breadth of third sternebra at its waist are not showing significance in the present study. **Conclusion:** By application of binary logistic multivariate discriminant analysis technique 95% male and 45% female sterna can be sexed correctly.

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## 1. Introduction

The human sternum is a flat elongated shield of bone that forms the middle of the anterior part of thoracic cage and protects the inner vital organs. Amongst the millions of human beings living on this earth no two persons are alike in all their measurable characters. Sex determination from unknown human skeletal remains or decomposed bodies is an important initial step in forensic investigation. Accurate determination of skeletal sex is a critical requirement in medico legal cases. The accuracy with which sex can be determined depends on the nature of materials available and methods applied. In the present study the sternum was subjected to statistical and morphological analysis to find out the percentage accuracy of its use in determination of sex.

The osseous skeleton of sternum is the only structure which resists the effect of putrefaction and decomposition for longer time. The ratio between manubrial and mesosternal lengths differs in the sexes. Racial differences in sterna have not been established. Hence, sternum is highly useful for determination of sex of an individual apart from determination of racial characters. Studies on sternum have been reported in both sexes of American, African and European population and also in different zones of Indian population like North Indian, Maharashtra and Gujarati population but not in South Indian population.

Metrical studies on the sterna in Marathwada region of Maharashtra concluded that out of all the parameters, the length of mesosternum (B) distinguishes 69.80% male and 76.60% female sterna [1]. By applying length of manubrium and length of mesosternum (M+B) 38.54% male and 57.45% female sterna can be sexed correctly [1]. By applying the multivariate linear discriminant analysis technique 92% male and 87% female sterna can be sexed correctly [1].

Very few reports are available in literature on racial and sexual variation in the sternum till now. Hence an attempt was made in the present work.

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## 2. Materials and methods

The human sternum is a flat elongated shield of bone that forms the middle of the anterior part of thoracic cage and protects the inner vital organs. Amongst the millions of human beings living on this earth no two persons are alike in all their measurable characters. Sex determination from unknown human skeletal remains or decomposed bodies is an important initial step in forensic investigation. Accurate determination of skeletal sex is a critical requirement in medico legal cases. The accuracy with which sex can be determined depends on the nature of materials available and methods applied. In the present study the sternum was subjected to statistical and morphological analysis to find out the percentage accuracy of its use in determination of sex.

- a) Length of manubrium (M): It is the distance from suprasternal notch to manubriomesosternal junction in midline. (X1)
- b) Length of mesosternum (B): It is the distance from manubriomesosternal junction to the mesosterno-xiphoidal junction in the midline(X2).
- c) Combined length of manubrium and mesosternum = M + B(X3)
- d) Breadth of first sternbrae at its waist = S1 (X4)
- e) Breadth of third sternbrae at its waist = S3 (X5)

From above measurements following two indices were obtained.

- I. Manubrio-corpus index =  $M/B \times 100$  (X6)
- II. Relative width index of first and third sternbrae =  $S1/S3 \times 100$  (X7).

The data obtained was analysed statistically to find out mean and standard deviation, t-value and p-value. As the bones are of unknown sex we have applied Fishers Z Statistic analysis to assume sex. By applying this test we have discriminated 79 observations in to 57 Males and 22 Females for each and every anthropometric variable by calculating Fishers Z Statistic and the distance between them. For that we have calculated the mean and standard deviations for the raw data and assumed as Z,

Where  $Z = (X - \text{mean}) / \text{SD}$ .

We have calculated Z1 and Z2 for (for males and females) using the formula:

(Males)  $Z1 = (X - \text{Male mean}) / \text{Male SD}$

(Females)  $Z2 = (X - \text{Female mean}) / \text{Female SD}$

We have further obtained absolute values Z, Z1, Z2. The distance between Z, Z1 and Z, Z2 are obtained by using the relation, Abs (Z-Z1) and Abs (Z-Z2). We have identified and discriminated that the variable under Male as Abs (Z-Z1) < Abs (Z-Z2) otherwise it is identified as Female. We have calculated Z, Z1, Z2, Abs (Z), Abs (Z1), Abs (Z2), Abs (Z-Z1) and Abs (Z-Z2).

After discrimination in to Males and Females their mean and standard deviations are obtained by entering data in Microsoft Excel Sheet. Means of continuous variables were compared by using student independent t-test. Discriminant analysis was conducted for each variable and the Wilks lambda, correctly classified percentage along with the percentage of accuracy for males and females were calculated. The Wilks lambda is the ratio of the within group and total sum of squares. Values close to Zero imply high predictability of membership.

## 3. Results

The results obtained, Basic Statistics and discriminant analysis of each variable were tabulated in Table 5.1.

## 4. Discussion

In the present study 79 adult sterna of unknown sex were subjected to morphological, morphometric and statistical analysis to find out the percentage of accuracy with which it facilitates determination of sex. Mean values for length of manubrium in males is 47.48 in the present study which is in accordance with studies of Dahipale et al., [1] but in females it is 21.68, a value that is not in relevance with any of the reported studies. It is showing 100% accuracy to sex females and is statistically significant and the difference in mean length is 25.8.

Mean values for length of mesosternum in males is 92.36 which is matching with previous studies and in females it is 88.95. As the difference between mean values is less it is statistically insignificant. Dahipale et al., [1] found that length of mesosternum is extremely useful in determining sex of sterna in Marathwada region of Maharashtra. These findings are correlating with those reported in literature [2, 3, 4, and 5]. But in our study this parameter is showing 83.05% of accuracy for males and 22.72% for females.

In the present study combined mean length of manubrium and mesosternum is having 100% of accuracy to sex females and 68.42% to sex males. The difference between mean values of males and females is 28.91 which is highly significant and is in agreement with previous studies conducted on Indian population by Dahipale et al., [1]. The present observations suggest that combined mean length of manubrium and mesosternum acts as a best discriminator which is in agreement with previous literature authors [1,2,3,4,5,6,7,8].

According to Wenzel [9] manubrium in the two sexes, is almost equal in length, but the Mesosternum is proportionally longer in males than the females. This led to enunciation of Hyrtl's law, according to which manubrio corpus index (sterna index) exceeds 50 in females and is less than 50 in males. Dahipale et al [1] in their study concluded that 100% female and 52.20% male specimens obey the law. However, the manubrium – corpus indices of one sex fall within the range of other sex in 95% cases. Therefore, the law when applied to an individual specimen is not helpful in determining the sex. This is in agreement with Ashley [3] and Jit et al [2] who found the law to be 'unreliable.' In our study though the difference between the mean values is more it is statistically insignificant and this parameter is failing to sex sterna which are in accordance with previous literature.

In the present study the difference in mean values for width of first sternebra is 25.59 which is statistically significant in accordance with study conducted by Atal et.al [10]. It is showing 90% of accuracy to sex males. Though width of third sternebra is statistically significant it is showing only 2.77 differences in mean values so it does not help in discrimination.

Ashley [3] described an index  $S1/S3 \times 100$ . In the present study difference in mean values up to 70.99 were observed and are statistically significant. This parameter is showing 92.98% of accuracy to sex males and 72.27% of accuracy to sex females. Though these values do not match with previous literature it can be inferred that width index also acts as a good discriminator.

**Table 5.1: Mean, SD, wilks Lambda, Discriminate function of different variables**

| Variables                        | Mean (in mm) |         | SD (in mm) |         | t    | Sig    | Discriminate functions |                                  |
|----------------------------------|--------------|---------|------------|---------|------|--------|------------------------|----------------------------------|
|                                  | Males        | Females | Males      | Females |      |        | Wilks Lambda           | Correctly classified (%)         |
| Length of manubrium (M)          | 47.48        | 21.68   | 12.029     | 5.963   | 9.59 | 0.0004 | 0.456                  | 68.35%<br>56.14%(M)<br>100%(F)   |
| Length of Mesosternum (B)        | 92.36        | 88.95   | 14.032     | 8.925   | 1.06 | 0.0315 | 0.986                  | 68.35%<br>83.05%(M)<br>22.72%(F) |
| Combined length (M+B)            | 139.55       | 110.64  | 21.093     | 8.127   | 6.23 | 0.0002 | 0.665                  | 77.21%<br>68.42%(M)<br>100%(F)   |
| Manubrium Corpus Index (M/B*100) | 52.07        | 25.04   | 13.545     | 10.726  | 8.39 | 0.0220 | 0.522                  | 69.62%<br>94.73%(M)<br>4.54%(F)  |
| Width of First Sternebra (S1)    | 53.32        | 27.73   | 13.497     | 7.119   | 8.43 | 0.0026 | 0.52                   | 79.74%<br>89.47%(M)<br>54.54%(F) |
| Width of third sternebrae (S3)   | 33.41        | 30.64   | 6.72       | 5.695   | 1.71 | 0.0052 | 0.963                  | 88.60%<br>96.49%(M)<br>68.18%(F) |
| Relative Width Index (S1/S3*100) | 161.18       | 90.19   | 35.153     | 9.635   | 9.30 | 0.0005 | 0.471                  | 88.60%<br>92.98%(M)<br>77.27%(F) |

**Fig.1. Combined length of manubrium and Mesosternum**



**Fig.2. Width of first sternebrae**



#### 4.1. Multivariate analysis

In the present study the data was subjected to BINARY LOGISTIC multivariate discriminant analysis technique as given by Armitage [11] and by this method 95% male and 45% female sterna can be sexed correctly. Jit et al [2] also applied multivariate analysis and they found that 89% male and 82% female sterna could be sexed correctly. Dahipale et al [1] also applied the multivariate discriminant analysis technique and they succeeded in sexing 92% males and 87% female sterna.

#### 5. Conclusion

In the present study 79 unknown fully ossified sterna collected from different Medical institutions were differentiated into 57 male and 22 female sterna by applying FISHER'S Z STATISTIC analysis test and the specimen were observed for 7 variables viz., Length of manubrium, mesosternum, combined length of manubrium and mesosternum, manubrio-corpus index, breadth of first sternebra at its waist, breadth of third sternebra at its waist and relative width index of first and third sternebrae.

Mean, standard deviation and percentage of accuracy was calculated for these parameters for both sexes. P value, t value and correctly classified sexing accuracy were calculated for the variables. In the present study the data was also subjected to BINARY LOGISTIC multivariate discriminant analysis technique as given by Armitage (11).

The following conclusions were drawn based on the present study-

- Length of manubrium may act as a good discriminator of female sterna as it is showing 100% of accuracy.
- Combined mean length of manubrium and mesosternum acts as a best discriminator to sex unknown sterna.
- Width of first sternebra is acting as a good discriminator to sex males.
- Relative width index is also useful to differentiate sex of unknown sterna.
- Remaining parameters are not showing significance in the present study.
- By application of binary logistic multivariate discriminant analysis technique 95% male and 45% female sterna can be sexed correctly.

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