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Sexual dimorphism of the human sternum in a Maharashtrian population of India: A morphometric analysis

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Abstract

Determination of sex from human skeletal remains is an imperative element of any medicolegal investigation. Length of manubrium, length of mesosternum, and combined length of manubrium and mesosternum were measured in 115 sternums of confirmed sex (75 male and 40 female) for sexual dimorphism. Application of "the 50 rule" for the manubrium confirmed sex in 77.3% male and 77.5% female bones, while application of "the 81 rule" for the mesosternum confirmed sex in 73.3% male and 75% female bones accurately. Application of "the 131 rule" derived from the study for combined length of manubrium and mesosternum confirmed sex in 85.3% male and 77.5% female sternums correctly. This study confined to the Maharashtra region of western India is useful to determine the sex of the sternum when it is subjected for medicolegal skeletal examination.

Keywords: Sternum; Sex determination; Morphometric analysis; Skeletal remains; Forensic anthropology

1. Introduction

Identification of sex from human skeletal remains is an imperative element of any medicolegal investigation, and a challenging task for forensic experts and physical anthropologists. The osseous skeleton which resists putrefaction for a long time is useful for sexing the individual. Sternum is one such bone which is being extensively studied for its sexual dimorphism. Sternum is confined to land vertebrates. The elongate human form is typical of mammals, where the sternum occupies the middle portion of the anterior thoracic wall. It is formed by the fusion of two cartilaginous sternal plates along the mid-ventral line, and consists of three parts, manubrium, body (mesosternum) and xiphoid process.

Sexual dimorphism in human sternum was first noted by Wenzel [1]. His findings were supported by Feigal, Hyrtl, and Dwight [2–4]. Paterson recorded that mesosternum was longer and narrower in males than in females [5]. For sexing the European sternum, Ashley [6] formulated "the 149 rule", according to which a male sternum exceeded 149 mm in length, whereas the female sternum was less than 149 mm. Jit et al. [7] successfully applied

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"the 136 rule" derived by Ashley [6] for East African population on the North Indian population, and Dahiphale et al. [8] formulated "the 129 rule" for Marathwada region in India. Rother et al. used discriminant function analysis based on length, breadth and thickness of sternum for sex determination successfully [9].

Standards of morphometric sex differences in the skeleton may differ with the population sample involved and thus cannot be applied universally. This is especially true with reference to dimensions and indices (average and range). As a rule, standards should be used with reference to the population from which they were drawn and upon which they are based [10]. The present study is an attempt to sex the manubrium, mesosternum, and sternum as a whole, on the basis of morphometric analysis in the Maharashtra region of western India. The article compares the findings of our study with those of other studies done worldwide and aims to derive a limiting point for the present study population group.

2. Materials and methods

One hundred and fifteen adult human sternums of confirmed sex (75 male and 40 female) were obtained from Government Medical Colleges at Miraj, Sholapur, Aurangabad and Kolhapur in Maharashtra region of western India. Only adult bones obtained from cadavers dissected during 1998 and 2002, with complete ossification were included in the study. Bones showing any fracture or gross pathology were excluded. The measurements were taken in millimeters according to the technique described by Ashley [6] with the help of vernier calipers to the nearest millimeter. All sternums within the study sample belonged to individuals of known age (range: 25–40 years old) from Maharashtra region of western India. The morphometric parameters of the sternum studied were as follows;

1. Length of manubrium (M): the distance from the suprasternal notch to the manubriosternal junction in the midline.
2. Length of body/mesosternum (B): the distance from the manubriosternal junction to the mesoxiphoid junction in the midline.
3. Combined length of manubrium and mesosternum ($M + B$): the respective measurements M and B were added.

The length of xiphisternum was not taken into consideration in this metric study because of high variability of xiphisternal length [11]. Moreover, as the specimens go old it usually dries, become short, or may be lost thus leading to erroneous calculation. The data obtained were computed and analyzed with SPSS (Statistical Package for Social Sciences, version 10.0) computer software. Student's t-test was performed to test the level of significance for difference between means and p-value <0.05 was considered as significant. Based on overlapping values, identification point (IP) and limiting point (LP) were derived for each parameter to find sexual dimorphism of sternum in the Maharashtrian population of western India. "Identification point" is derived based on the overlapping range of the sample and "limiting point" is derived from the average of male and female identification points. A dividing line between the two genders (rule) is arrived at by "trial and error" for each parameter based on limiting point.

3. Results and discussion

Various measurements of sternum are shown in Table 1. It shows that the difference between mean value for each parameter in both genders is highly significant ($p < 0.001$). Distribution of cases for length of manubrium, length of mesosternum, and combined length of manubrium and mesosternum is shown in Figs. 1–3.

3.1. Length of manubrium

The length of manubrium in male sternums ranges from 43 to 70 mm with mean length of 51.99 mm, and in female sternums it ranges from 32 to 57 mm with mean length of 44.88 mm. The difference between mean length of male and female manubrium is 7.11 mm which is statistically highly significant ($p < 0.001$) and higher than those observed in other studies. Difference between means in other studies was found to be varying between 1.7 and 4.7 mm [4–8].

Identification points 57 and 43 are derived for males and females respectively based on the overlapping range (43–57 mm). Manubrium with length above 57 mm was designated male, and with length less then 43 mm was designated female. Thus, 13.3% of male sternums and 27.5% female sternums could be sexed accurately. Although low, sexing accuracy of manubrium based on identification point analysis in our study is higher when compared to observations of other researchers [4–8]. Limiting point 50 was derived for the study sample. Manubrium measuring 50 mm and above is suggestive of male sex and less then

Table 1
Different measurements of sternum in males and females (mm)

Parameter	Male ($n = 75$)			Female ($n = 40$)		
	Mean	SD[a]	Range	Mean	SD[a]	Range
Length of manubrium (M)	51.99[b]	4.96	43–70	44.88[b]	5.26	32–57
Length of mesosternum (B)	89.17[b]	10.63	65–120	72.38[b]	12.76	42–95
Combined length ($M + B$)	141.16[b]	11.03	120–173	117.25[b]	16.25	79–140

[a] Standard deviation.
[b] $p < 0.001$.