



Manubrio-corpus index: Is it a reliable indicator for sex determination

Mahesh Chand Meena*, Mukta Rani, Yashoda Rani

Department of Forensic Medicine and Toxicology, Lady Hardinge Medical College and Associated Hospitals, New Delhi, India

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Abstract: Determination of sex by an examination of the skeleton remain is important in identification of an individual when only skeleton remains are presented to an expert. The present study was designed to determine the sex of the sternum by using sternal index (manubrio-corpus index) as a parameter to examine the sexual dimorphism in a population specific autopsy sample using discriminant function analysis on 100 adult bones (50 male and 50 female). The results of this study shows that sex determination cannot be made conclusively from the sternal index (manubrio-corpus index).

Key words: Human identification, sternum, sex determination, discriminant function analysis

Manubrio-corpus indeksi: Cinsiyet tayininde güvenilir bir kriter midir?

Öz: Bir uzmana sadece iskelet kalıntıları sunulduğunda, bireyin kimlik saptamasında bu kalıntıları inceleyerek cinsiyetini belirlemek önemlidir. Bu çalışma, otopsi örnekleri üzerinde diskriminant fonksiyon analizi kullanarak 100 yetişkin sternum kemiğinin (50 erkek ve 50 kadın) taşıdığı cinsel karakteri (dimorfizm) inceleme amaçlı olup, bunu, sternal indeksin (manubrio-corpus indeksi) karakteristik özelliklerinden yapmak üzere tasarlanmıştır. Çalışmanın bulguları, sternal indekse dayalı olarak güvenilir bir cinsiyet tayininin yapılamayacağını göstermektedir.

Anahtar kelimeler: Kimliklendirme, sternum, cinsiyet tayini, diskriminant (ayırım) analizi

Introduction

The individual thoracic region is relatively important in forensic anthropological studies. It is possible to determine sex accurately from the skeleton; it is not always possible to recover all skeletal bones at the same time in forensic practice. It is therefore important to obtain as much information as possible from each bone and extract information such as age and sex concerning the bone's owner when analyzing even a single bone (İşcan, 1985). Sex and age determination is most important data that can be obtained from bones.

A difference in the ratio between the length of the manubrium and that of mesosternum in the two sexes was first described by Wenzel (1788). His findings were supported by Hyrtl (1893), and Dwight (1890). According to the Hyrtl's law the ratio between the length of the manubrium and that of the mesosternum is more than 1:2 in the case of women, and less in men. Paterson (1904) recorded that the mesosternum was longer and narrower in the males than in females. For sexing the European sterna Ashley (1956) formulated the '149 rule,' according to which a male sternum exceeded 149 mm in length, whereas the female sternum was less than 149 mm. To sex the North Indian sterna Jit et al. (1980) showed that the said rule was not applicable to Indian sterna, which were shorter in length. The present work is an attempt to sex the sterna in Marathwada region of Maharashtra on the basis of metrical study.

Although non-metric measurements were first used for sex determination from the skeleton in the literature, objective metric measurements were used later on (İşcan, 1985; Ashley, 1956; Jit et al., 1980; Dahiphale et al., 2002; İşcan et al., 1984; McCormick et al., 1985). Metric measurements are preferred because of their easy repeatability, high accuracy and the lack of a requirement for special expertise (McCormick et al., 1985). One of the first metric methods, Hyrtl's Law (Hyrtl, 1893), has been using sternal size for over 170 years as an estimator of sex. According to Hyrtl, in females the manubrium generally exceeds half the length of the sternal body whereas in males the body of the sternum is usually twice as long as the manubrium. Numerous other investigators have used sternal or thoracic area measurements as useful predictors of sex (Hyrtl, 1893; Dwight, 1881; Dwight, 1890; Paterson, 1904; Pons, 1956; Ashley, 1956; Jit et al., 1985; İşcan, 1985; Stewart et al., 1983). The anterior thoracic cage has been analyzed by direct measurement of dried sternums from cadavers or indirect measurement of images obtained from chest radiographs in various studies later on (İşcan, 1985; Ashley, 1956; Jit et al., 1980; McCormick et al., 1985; Torwalt et al., 2005). Various rules such as "the 149 rule" (Ashley, 1956) and "the 136 rule" (Jit et al., 1980) for determining sternal length using the measurements taken from the same level at the sternum have been defined in the literature. These defined rules have been developed on the basis of measurements smaller ones belonging to females and larger than the cut-off point belonging to males. Different population groups such as American Whites and Blacks have been thought to be the main reason for the different numbers in the rules (Wiredu et al., 1999; Kocak et al., 2003). Some studies have emphasized that the sex determination accuracy can be increased when 4th rib measurements and the rib mineralization pattern are taken into account in addition to sternal data (İşcan, 1985; McCormick et al., 1983). The present study was designed to identify these morphological features (predictors) and examine the sexual dimorphism of adult sternum in a population specific sample applying linear discriminant function analysis. The purpose was to examine how a combination of these newer variables discriminated between the two sexes in a population specific sample. The variables used in the present series were new and taken from direct measurement at autopsy in wet bone sample.

Materials and Methods

The present study consists of 100 sternums obtained from known male and female (50 Male and 50 Female) dead bodies brought for medico-legal autopsy. As sex differentiating features in the bones are well marked only after puberty and pieces of mesosternum complete fusion by the age of 25 years, sternums of individuals above 25 years of age were taken for the present study. The various dimensions were measured by using Helio's Dial Caliper, which gives more accurate reading, up to 1/ 100 of mm. The following dimensions of sternum were measured in millimetres and evaluated.

- Length of manubrium (X)
- Length of mesosternum(Y)

- Manubrio-corpus index or Sternal index (S.I.) = $X / Y \times 100$

Metric data was summarized as mean and standard deviations. Discriminant function analysis was done to examine the dimorphism in sternum and how the variables could correctly assign the bones to the proper sex. Statistical analysis was done using SPSS. The p value was determined to find out whether the sexual differences between means were significant or not. The data was also analysed statistically to find out the reliability of sternal Index in determination of sex and to find out the number of cases lying in overlapping zones. Ethical approval given by Lady Hardinge Medical College.

Observations and Results

The results of descriptive statistics related with sterna measurements and ratios of the present study are shown in Table 1 and 2.

Table 1. Descriptive statistics related for sterna measurements related with sex

Parameters	Sex	Range	Mean	S.D.	Level of significance
Length of manubrium (X)	M	36.5-54	44.49	3.14	P < 0.001
	F	35-48	40.45	3.19	
Length of mesosternum (Y)	M	83-107	101.16	5.79	P < 0.001
	F	63-94	78.96	5.89	
Combined length (X+Y)	M	119-161	145.66	6.70	P < 0.001
	F	98-132	119.41	7.67	
Manubrium-Corpus Index (X/Y × 100)	M	36-55	44.89	3.57	P < 0.001
	F	47-64	57.37	3.82	

Table 2. Percentage of cases falling in overlapping zone

Parameter	Sex	Number of cases in overlapping zone	Cases in overlapping Zone (%)
Manubrium-Corpus Index (X/Y × 100)	M	36	72
	F	41	82

In the present study, it was observed that the mean sternal index was 44.89 for males and 57.37 for females. The level of significance of the difference between the means was statistically highly significant ($p < 0.001$) for sternal index (Table 1). Out of 50 males sternums, 36 male cases (72%) were lying in overlapping zone while of the 50 female cases, 41 cases (82%) were lying in overlapping zone. Only 14 male and 9 female cases were not lying in the overlapping zone (Table 2). In spite of significant p value ($p < 0.001$), for the difference between sternal index of male and female (Table 2, Figure 1), the sternal index could not be considered as a reliable parameter for sex determination. It could be due to overlapping of maximum sternal indices among both males and females

Discussion

Wenzel (1788) stated that the manubrium in the two sexes, is almost equal in length, but the mesosternum is proportionally longer in male than females. This led to enunciation of Hyrtl's law according to Hyrtl's law; manubrio corpus index (sternal index) exceeds 50 in females and is less than 50 in males.¹ Table 4 gives the observations of various workers regarding the percentage of cases obeying the Hyrtl's law in the two sexes.

In the present study it was observed that the mean sternal index in male and female were 44.89 and 57.37 respectively. The average difference between the sternal index in two sexes was 5.74 which was statistically highly significant ($p < 0.001$). This is in agreement with Atal et al. (2008) found mean sternal index in male and female were 46.089 and 56.703 respectively

In the present study also observed that 85% male and 78% female specimens obey the Hyrtl's law (Table 4). However, the overlapping between the manbrio-corpus indices of two sexes was also 77.00% (Out of 100, 36 male and 41 female). Therefore, the law was not reliable when applied to an individual specimen in determining the sex. This is in agreement with Ashley (1956), Jit et al. (1980) Dahiphale et al. (2002) and Atal et al. (2008) who found the law to be 'unreliable.'

Jit et al. and Dahiphale applied the discriminant function to increase the accuracy of sex determination of sternum. Jit et al. (1980) found that 89% male and 82% female sterna could be sex correctly and Dahiphale et al. (2002) found that 92% male and 87% female sternum can be sex correctly by using discriminant functions (multivariate discriminant analysis).

In the present study also, the discriminate function were generated and found that by using discriminant functions 91.7% male and 94.6% female can be sexed correctly.

Table 3. Percentage of cases obeying Hyrtl's law as recorded by various authors

Observer	Number of cases	Sex	Percentage of cases obeying the law
Dwight (1890)	142	M	59.10
	86	F	60.40
Patermoller (1890)	55	M	65.00
	33	F	-
Krause(1897)	-	M	-
	14	F	43.00
Ashley (African) (1956)	85	M	64.70
	13	F	69.20
Ashley(European) (1956)	378	M	52.90
	171	F	69.30
Narayan and Varma (1958)	126	M	34.12
	27	F	81.48
Jit et al. (1980)	312	M	31.08
	88	F	88.64
Dahiphale et al. (2000)	96	M	52.20
	47	F	100.00
Atal (2008)	56	M	89.28
	44	F	75.00
Present Study	50	M	85.00
	50	F	78.00

Conclusion

Sex determination is one of the principal elements in practical forensic casework involving examination of skeletal remains. The present study found that Manubrio-corpus index (sternal index) is unreliable for sex determination.

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