Is Human Sternum a Tool for Determination of Sex?

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Abstract

Background & objectives: Determination of sex is a vital part of medico-legal practice. The objective of the study was to obtain cut off values for determination of sex by measuring the length and breadth of manubrium and body of sternum.
Methods: Through dissection and maceration of soft tissues, 103 sterna (53male and 50female) between 15 years to 75 years were obtained from known corpses during medico-legal autopsies at Tirunelveli Medical College, Tamilnadu, India.
Results: This study revealed that it could be a male if the **l**ength of body of sternum is greater than 87mm, length of manubrium is greater than 50mm, breadth of body of sternum is greater than 38 mm, breadth of manubrium is greater than 60mm, combined length of manubrium and body of sternum is more than 136mm and sternal index is 47 or below whereas it could be of female if the length of body of sternum is less than 72 mm, breadth of manubrium is less than 48 mm, breadth of body of sternum is below 29 mm, combined length of manubrium and body of sternum is below 119 mm and sternal index is 70 or above.
Interpretation: Higher percentage of accuracy is found with length of body of the sternum, combined length of manubrium and body of sternum in both sexes, whereas they are more reliable in males.
Conclusions: This study proves that the sternum is a reliable bone to determine the sex of a person.

Key words: Body of sternum, Identification, Manubrium, Sex.

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Introduction

Identity of a person is important, both in life and death. In medico-legal practice, determination of this identity is equally important. This is aided by forensic medicine experts. The establishment of the uniqueness of a person becomes very useful when the identity cannot be settled as in cases of mass disasters like air crash, fire accidents, explosions, etc. What can make the process of identification more difficult is mutilation of body parts, decomposition and ruined fragments or remnant body parts. Before identification of a person using the skeletal remains, a bigger task remains – to identify whether the bones belong to man or to some other species. Determination of the sex from the bones can be undertaken as a primary investigation for identification as sex plays a characteristic role in identifying the individual. Unlike stature, sex follows only one direction and does not go backwards. This presents as a small advantage when sex is the parameter used for identification. Numerous methods have come into play to determine the sex from any part of a skeletal remain as lengths of different body parts have a consistent association with it.

Forensic experts usually end up getting bones in establishing identity. This they do by estimating the age, sex and stature of the person from dismembered body parts and bones. Important conditions to establish identity are age, sex and stature. Other such criteria include racial features, moles, scars, professional marks and complexion which remain the same throughout life.

This study was done to assess the sex of the individual to help in identification as sternum is a sturdy bone and can be obtained from highly decomposed bodies[1]. Being superficial, it can be got without much destruction. Also, it can be acquired from bodies safely, without major skilful procedures during a post-mortem.

Materials and Methods

The sternum which was selected as the material of study, were obtained from 103 known corpses aged between 15years and 75years from Tirunelveli medical college, Tamil Nadu, India. Corpses that were compressed, burned or extremely mutilated were excluded and sterna with congenital and acquired deformities as well. During the process of medico-legal autopsies, the costochondral junctions were dissected, sterno-clavicular joints were detached and finally the soft tissues of the sternum were removed manually and

dried[2]. Anatomical method and the mathematical method are the two methods by which sex can be assessed. The sex can be found out by naked eye examination from their anatomical variations. But accuracy is low in this method. In mathematical method, sex can be evaluated by measuring the various distances between bony points and creating the index for reconstruction of sex[3]. Owing to the requirement of a single bone, the mathematical study was chosen for this study. Measurements were taken by using digital vernier calliper.

Length of manubrium is measured from the jugular notch to the lower end of manubrium. Length of body of sternum was measured from the junction of the manubrium and body of sternum to the junction of body of sternum and Xiphoid process. Combined length of manubrium and manubrium and body of sternum was measured from the jugular notch to the junction between body of sternum and Xiphoid process. Breadth of manubrium was measured between the articulating surfaces of clavicles. Breadth of body of sternum was measured at its widest part[4].

Osteometric Parameters (Fig. 1 & 2) Used:

1. Combined length of manubrium and body(LMB)
2. Length of body of sternum(LB)
3. Length of manubrium(LM)
4. Breadth of manubrium(BM)
5. Breadth of body of sternum(BB)
6. Sternal index: calculated based on the relative size of the manubrium and the body of the sternum, expressed as:

$$\frac{\text{Length of manubrium}}{\text{Length of body}} \times 100$$

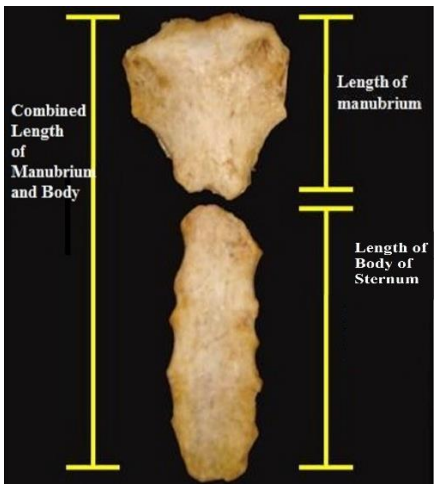

Fig. 1: Measurements of Sternum

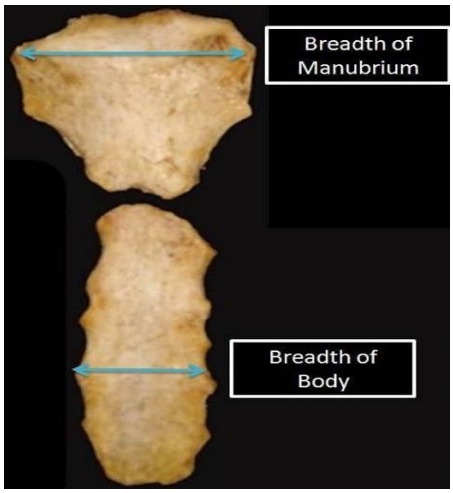

Fig. 2: Measurements of Sternum

Observation

Data collected was recorded, tabulated and statistically analyzed. Minimum, maximum, mean, median and Standard Deviation of the measurements for both males and females separately in the Table 1.

The Difference in the mean value of LB is significantly greater (18.6) in males.

In the total observations noted, there was no female with LB greater than 87mm. Hence we can infer that a person with the LB greater than 87mm could be a male. Moreover there was no male with the LB less than 72mm. So we arrive at the conclusion that a person with the LB less than 72mm could be a female.

The difference noted in the mean LM is 3.8 mm which is highly significant from the statistical point of view. If the LM is more than 50 mm it could be a male as there was no female with a value above this.

The difference of 5.6mm in the mean of BB is highly significant here as the variable has only a small measurement. It was noted that there was not even a single female with a measurement greater than 38mm. Hence we can assume that a sternum of an unknown could be male if the BB is greater than 38mm. Moreover there was no male with the BB less than 29mm. So we can infer that a sternum having BB less than 29mm could be a female.

There was no female with a BM greater than 60mm, so it can be concluded that a sternum having BM greater than 60mm could be a male. Moreover, there are no males with the BM less than 48mm, hence we decide that, if the BM is less than 48mm could be a female individual.

Mean LMB is significantly higher in males. There were no females with LMB of greater than 136mm. Hence we can assume a person as male if the value measured is more than 136mm. Moreover, No males were with a LMB of less than 119mm. So once again we can infer that a sternum with the LMB below 119mm could belong to a female individual.

Mean sternal index was significantly higher in females. All the males showed a sternal index of 69.4 or below. At the same time, all females showed the sternal index of 47.1 or above. So we can very well conclude that a sternum with the sternal index of 70 or above could be a female and 47 or below could be a male.

Discussion

Study of sternum as an individual parameter for determination of sex has been attempted by various workers. First recorded data was from Wenzel (1788), who described that the LB was proportionally longer in males than the females but the manubrium in two sexes was almost equal in length.[5]

The Results of studies on sternum by various researchers and the present study have been given in the Table 2.

A study on Africans revealed that the BM ranged from 15 to 45mm in both sexes, with in this range the overlap of the sexes were from 26 to 38mm.[13]

It is quite obvious from the foregoing observations that all parameters measured have a higher value in males except sternal index which is greater in females. This is in total agreement with previous studies.[14,15]

All the parameters of the sternum (i.e.) the LB, LMB, BB, BM and sternal index showed significant statistical difference between males and females. When the LM was taken into consideration, it was found to be of not much significance, since a specific cut – off value could not be found out for females (Due to the values below 50mm were equivocal). This is in good agreement with the observations of previous workers[9] who were of the opinion that LM is not a useful index in sexing a given sternum.

The LM exceeds half the LB of the sternum in females while in males; the LB is at least twice the LM. This view which was put forward by many authors and workers[16,17] has also been noticed in the present study. This observation could also explain the reason for the statistical non-significant difference in the measurements of LM in males and females.

The LB is found to be significantly higher in males (94.1mm) than females (75.5mm) The LMB is also significantly higher in males (142.7mm) than in females (119.3mm) which are in close agreement with previous studies[5,15,18]

Some studies conducted by other researcher[8] provided two cut off values for sex determination i.e. a value above which the sternum could be sexed as male and below which it could be female. The present study shows that a significant number of sterna fall within the equivocal range only.

So in order to avoid such ambiguities, the present study mentions only of a definite cut off value above or below which the sternum can actually be sexed. This study also provides the mean value for each and every measurement (sex – wise) which would help to give an idea regarding the sex of the individual. But this conclusion was observed leaving out the group which was equivocal. The inability to determine the sex for those sterna having measurements within these limits seems to be obvious in all previous studies.[7,9,14] For the sterna with the equivocal range, sex can be identified with the help of other bones.

Accuracy is more with LB and LMB in both sexes. When we take as a whole, LB and LMB in males are more reliable parameters.

Table 1: Showing maximum, minimum mean, median, and standard Deviation of the measurements for both males and females

	Minimum		Maximum		Mean		Median		SD (±)		P Value
	M	F	M	F	M	F	M	F	M	F	
LB in mm	72	54	108	87	94.1	75.5	95	77	9.0	9.3	p<0.0001
LM in mm	38	39	60	50	49.6	45.8	50	45	5.6	3.9	p<0.001
BB in mm	29	22	48	38	36.9	31.3	36	32	4.5	5.4	p<0.0001
BM in mm	48	40	74	60	60.7	52.2	61	52	6.3	5.5	p<0.0001
LMB in mm	119	98	160	136	142.7	119.3	142	114	10.1	11.3	p<0.0001
Sternal index	37.3	47.1	69.4	90.7	52.3	60.6	51	59	8.4	9.0	p<0.001

LB-Length of Body of Sternum. LM-Length of Manubrium. BB-Breadth of Body of Sternum. BM-Breadth of Manubrium. LMB-Combined length of Manubrium and Body. SD-standard deviation. M-Male, F-Female.

Table 2: The Results of studies on Sternum by various researchers and present study

Author	Sternal parameters											
	LM		LB		LMB		BM		BB		Sternal Index	
	M (m.m)	F (m.m)	M (m.m)	F (m.m)	M (m.m)	F (m.m)	M (m.m)	F (m.m)	M (m.m)	F (m.m)	M	F
Dwight (1881)[6]	51.80	46.70	105.90	89.40	-	-	-	-	-	-	-	-
Dwight (1890)[7]	53.70	49.40	110.40	91.90	164.10	141.30	-	-	-	-	-	-
Ashley (1956) African Study[8]	45.90	44.20	91.90	96.50	142.60	127.10	-	-	-	-	-	-
Ashley (1956) European Study[8]	52.20	47.90	104.70	90.80	156.90	138.70	-	-	-	-	-	-
Jit I et al(1986)[9]	51.73	48.42	95.35	78.60	147.08	127.02	27.45	24.32	32.58	29.19	-	-
Gautam (2003)[10]	53	48	95	76	149	124	21-68	24-51	-	-	-	-
Dahiphal et al (2002)[11]	48.45	43.78	94.42	70.19	142.19	113.17	27.16	24.44	31.94	28.23	-	-
Muhit Gupta et al (2014)[12]	40.63	37.38	87.31	81.57	127.95	120.09	31.76	29.99	35.16	33.16	-	-
Present Study	49.6	45.8	94.1	75.5	142.7	119.3	60.7	52.2	36.9	31.3	52.3	60.6

LB-Length of Body of Sternum. LM-Length of Manubrium. BB-Breadth of Body of Sternum. BM-Breadth of Manubrium. LMB-Combined length of Manubrium and Body. BM-Breadth of Manubrium. BB-Breadth of Body of Sternum. SD-standard deviation. M-Male, F-Female.

Conclusion

The distinctiveness of an individual depends and varies as per provincial and biological variations. This fact has been verified in the past and in this present study. Hence, the strongest suggestion that has been derived from this study is that, regional wise in depth studies are essential in assessing the sex. However, this study demonstrates that sternum is one of the perfect means in determination of the sex of an individual, either in presence or in absence of bones like pelvis and skull.[19]

Conflicts of Interested: None

Source of Support: Nil

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