

A Prospective Autopsy based Study on Estimation of Sex from the Sternal Parameters at Mahatma Gandhi Memorial Government Hospital, Trichy

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Abstract

In forensic medicine, anthropological investigation and the identification of skeletal remains and the method to be employed for this purpose are always important. However, the partial or total destruction of long bones reduces the possibility of successful identification. Sternum resists the effects of putrefaction and decomposition for a long period of time. The present study was conducted to analyze the correlation between the sex and various measurements of the sternum.

Aim and Objectives: To determine sex of an individual from the sternal measurements.

Materials and Methods: The data for this particular study was collected from the medicolegal autopsy cases conducted at Mahatma Gandhi Memorial Government Hospital, Trichy. 150 intact sternums belonging to both the sexes aged more than 1 year and less than 40 years was taken as the study material.

Result: It was established that a subject may be male if the following conditions are present- The sternum's body is longer than 9.3 cms or more, Manubrium length is larger than 4.65 cms or more, the sternal index is 48.9 or less and the overall sternum is longer than 14.25cms or more. If the following conditions are present, a subject may be female - The sternum's body is lesser than 9.3cms, Manubrium length is lesser than 4.6 cms, the sternal index is 49 and more and the overall sternum is lesser than 14.25cms.

Conclusion: In our study, the length of body of sternum can be taken as the most reliable sternal parameter for determining the sex followed by the total sternal length. All the sternal parameters except the sternal index were on the higher limits for males.

Keywords: Sternum; sternal parameters; sex.

Introduction

Identification is the determination of the individuality of a person, whether living or dead¹.

It is one of the most important duties of the medico legal experts to assist the investigating agency. The medico legal expert's service in the field of identification is sought during mass disasters,

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advanced decomposition and extremely mutilated bodies, skeletal and fragmentary remains and much more. Apart from legal reasons, the identification is also important for civil purposes like dispute of inheritance, marital reasons, disputed sex etc., and for humanitarian reasons like identification of the deceased. Forensic Anthropology gained importance in recent days due to the fact that experts often have to rely on the bones in their work. Sex, race, age and stature is considered as the “big four” parameters in forensic identification. Other criteria for establishing the identity of an individual include moles, scars, color of an individual, tattoo marks, finger prints and DNA profiles¹. Many experts consider racial features in identification of an individual to be an outdated concept. For personal identification, determining sex is an important criterion. This task is easier if primary and secondary sexual characteristics of the individual are intact. However, in cases of concealed sex, intersex conditions or when only skeletal remains are available, a vast knowledge and careful scientific approach are required to ascertain the sex of the individual. The sternum is a superficial bone that can be easily procured without disturbing the routine autopsy procedures and remains intact even in the advanced decomposition. Considering these factors, the present study is an earnest effort to establish the sex of an individual through measurements of sternal parameters.

Research Gap:

- Limited Use of Sternal Measurements in Sex Determination** – While many studies have focused on pelvis and skull morphology for sex determination, research on the use of sternal parameters remains relatively limited.
- Variability in Population Data** – Existing studies on sternal measurements are often based on specific populations, and their applicability to diverse ethnic groups remains unclear.
- Lack of Standardized Methodology** – Different studies use varying measurement techniques and statistical analyses, leading to inconsistencies in results.

Need for the Study:

- Sternum and reliable parameters** – The sternum remain intact even in advanced decomposition and can be accessed without disrupting routine autopsy procedures, making it a reliable structure for sex determination when other skeletal elements are missing.
- Contribution to Population-Specific Data** – This study will help establish baseline sternal measurements for sex determination in a specific population, aiding forensic experts in more accurate identifications.

Aim and Objectives:

- To determine sex of an individual from the sternal measurements.

Materials and Methods

The present study was carried out in the Department of forensic medicine and toxicology, K.A.P.Vishwanatham Government Medical College and Mahatma Gandhi memorial government hospital, Trichy from November 2021 to April 2022. The study sample consisted of 150 deceased individuals who were subjected to medico-legal autopsy at the mortuary wing attached to Mahatma Gandhi memorial Government Hospital, Trichy.

To determine sex, the following osteometric parameters were used in the analysis:

- Total sternum length (TL)
- The length of the sternum's body (BL)
- Manubrium length (ML)
- Sternal index (SI):

$(\text{Length of manubrium} / \text{Length of body of the sternum}) \times 100$

A vernier caliper was used to measure the osteometric parameters.

Limitations of the Study:

We cannot perform this study, if there is any,

- Injury to the sternum.
- Deformities of chest wall - both congenital and acquired.

PHOTOGRAPHS



Fig 1: PROCEDURE OF REMOVAL OF STERNUM



Fig 2: MEASURING THE LENGTH OF MANUBRIUM STERNI BY DIGITAL VERNIER CALIPER

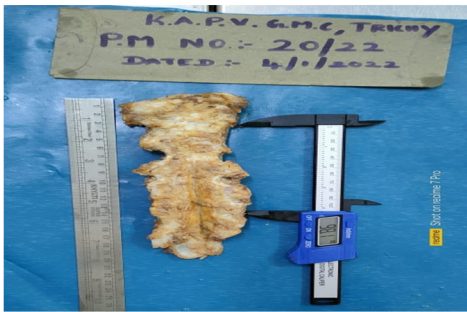


Fig 3: MEASURING THE LENGTH OF BODY OF THE STERNUM



Fig 4: MEASURING THE TOTAL STERNAL LENGTH

FINDINGS:

DISTRIBUTION OF THE PARTICIPANTS:

- 22.7% participants were in the age group 21 to 25 years followed by 20% in the age group 36 to 40 years.
- 72% participants were males and 28% were females.

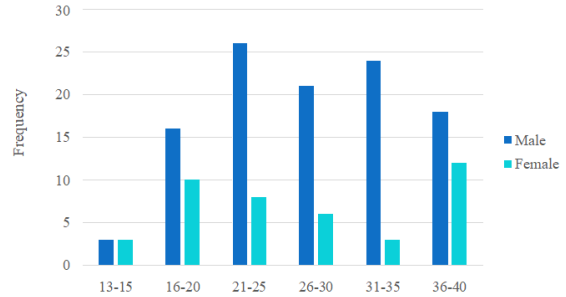


Fig 5: Bar chart showing distribution of participants.

DISTRIBUTION ACCORDING TO LENGTH OF MANUBRIUM:

46% participants were having manubrium length of 5.1 to 6 cms and 26.7% were having length of 4.1 to 5 cms.

Table 1: Distribution according to length of manubrium.

Variables	Frequency (n=150)	Percentage (%)
Length of manubrium (in cms)	2.9-4	28
	4.1-5	40
	5.1-6	69
	>6	13

DISTRIBUTION ACCORDING TO LENGTH OF BODY OF STERNUM:

46% participants were having length of body of sternum of 11 to 13 cms followed by 30% with length of 9 to 10.9 cms.

Table 2: Distribution according to length of body of sternum.

Variables	Frequency (n=150)	Percentage (%)
Length of body of sternum (cms)	<7	12
	7-8.9	24
	9-10.9	45
	11-13	69

DISTRIBUTION ACCORDING TO TOTAL STERNAL LENGTH:

56% were having sternal length of 14.1 to 18 cms followed by 24.7% with sternal length of 10.1 to 14 cms.

Table 3: Distribution according to total sternal length.

Variables		Frequency (n=150)	Percentage (%)
Total sternal length (in cms)	≤ 10	7	4.7
	10.1-14	37	24.7
	14.1-18	84	56
	18.1-20	22	14.7

DISTRIBUTION ACCORDING TO STERNAL INDEX:

40% were having sternal index of 45.1 to 48 followed by 31.3% with sternal index 48.1 to 51.

Table 4: Distribution according to sternal index.

Variables		Frequency (n=150)	Percentage (%)
Sternal index	42-45	14	9.3
	45.1-48	60	40
	48.1-51	47	31.3
	51.1-55	29	19.3

COMPARISON OF MEAN LENGTH OF MANUBRIUM BETWEEN MALE AND FEMALE:

The mean length of manubrium among the males was 5.31 ± 0.54 cms and that of females was 3.96 ± 0.52 cms. The mean length of manubrium was more among males than females with P value of less than 0.05.

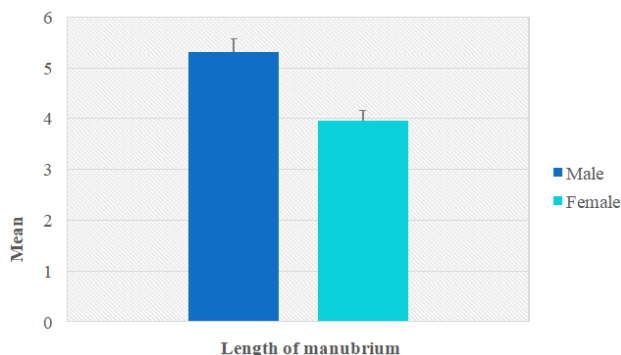


Fig 6: Bar chart showing comparison of mean length of manubrium between male and female.

COMPARISON OF MEAN LENGTH OF BODY OF STERNUM BETWEEN MALE AND FEMALE:

The mean length of body of sternum among the males was 11.28 ± 1.02 cms and that of females was 7.67 ± 1.11 cms. The mean length of body of sternum was more among males than females with P value of less than 0.05.

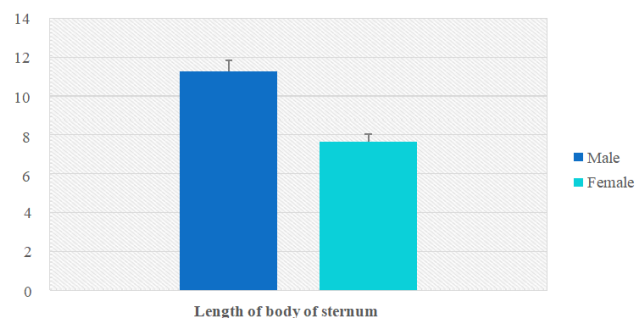


Fig 7: Bar chart showing comparison of mean length of body of sternum between male and female.

COMPARISON OF MEAN TOTAL STERNAL LENGTH BETWEEN MALE AND FEMALE:

The mean total sternal length among the males was 16.60 ± 1.54 cms and that of females was 11.64 ± 1.63 cms. The mean total sternal length was more among males than females with P value of less than 0.05.

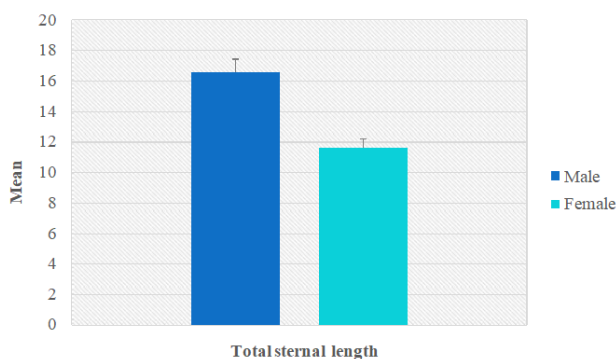


Fig 8: Bar chart showing comparison of mean total sternal length between male and female.

COMPARISON OF MEAN STERNAL INDEX BETWEEN MALE AND FEMALE:

The mean sternal index among the males was 47.04 ± 1.77 cms and that of females was 51.76 ± 1.67 cms. The mean sternal index was more among females than males with P value of less than 0.05.

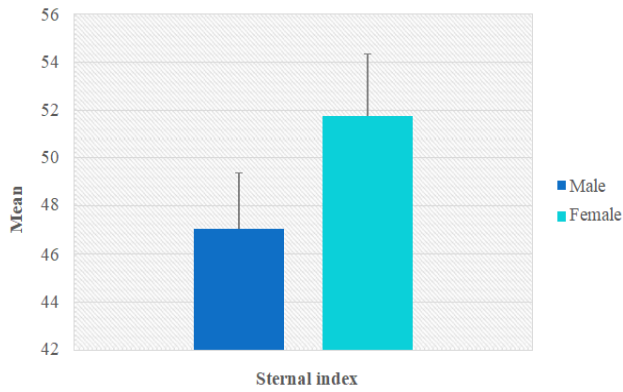


Fig 9: Bar chart showing comparison of mean sternal index between male and female.

ROC CURVE OF LENGTH OF MANUBRIUM FOR DETERMINING THE ACTUAL SEX:

- The area under the curve was 0.962 (95% CI 0.936 – 0.988).
- Length of manubrium could be efficient tool for determining male sex.
- Based on the co-ordinates the cut off determined was 4.65.
- If the length of the manubrium was more than or equal to 4.65cms, then it could be males and less than that of 4.65cms could be females.

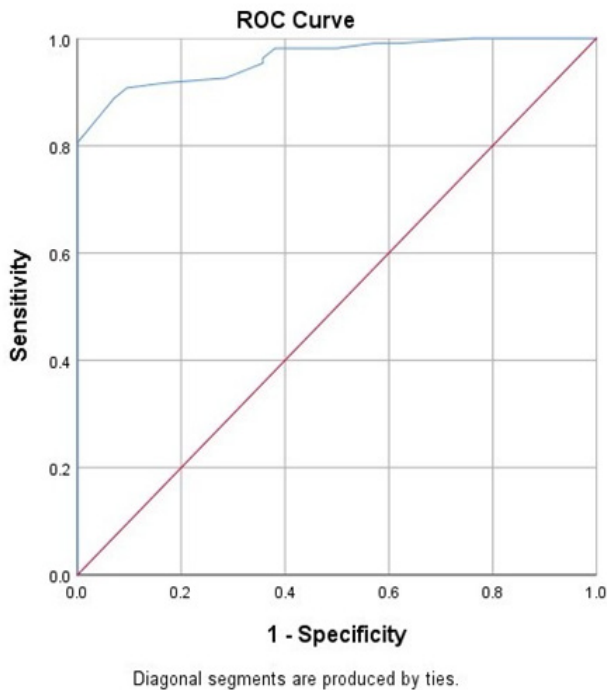


Fig 10: ROC curve of length of manubrium for determining the actual sex.

ROC CURVE OF LENGTH OF BODY OF STERNUM FOR DETERMINING THE ACTUAL SEX:

- The area under the curve was 0.989 (95% CI 0.974 – 1.00).
- Length of body of sternum could be efficient tool for determining male sex.
- Based on the co-ordinates the cut off determined was 9.3.
- If the length of body of sternum was more than or equal to 9.3cms, then it could be males and less than that of 9.3cms could be females.

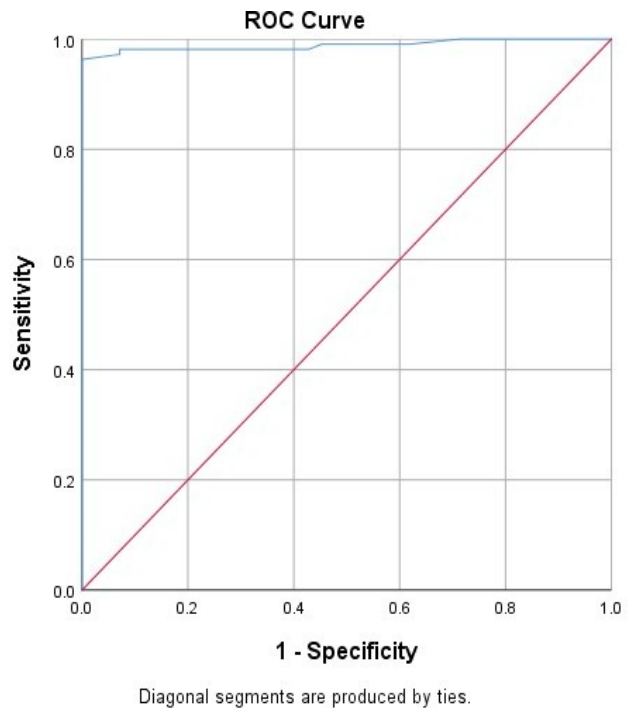


Fig 11: ROC curve of length of body of sternum for determining the actual sex.

ROC OF TOTAL STERNAL LENGTH FOR DETERMINING THE ACTUAL SEX:

- The area under the curve was 0.985 (95% CI 0.970 – 1.00).
- Total sternal length could be efficient tool for determining male sex.
- Based on the co-ordinates the cut off determined was 14.25.
- If the total sternal length was more than or equal to 14.25 cms, then it could be males and less than that of 14.25 cms could be females.

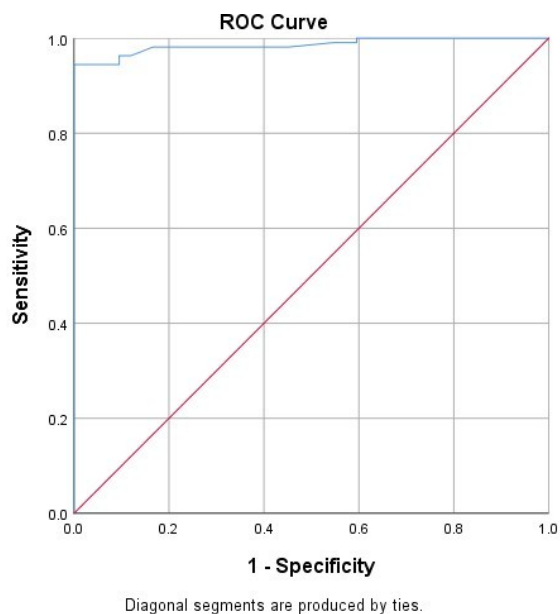


Fig 12: ROC of total sternal length for determining the actual sex.

ROC OF STERNAL INDEX FOR DETERMINING THE ACTUAL SEX:

- The area under the curve was 0.978 (95% CI 0.956 – 1.00).
- Sternal index could be efficient tool for determining male sex.
- Based on the co-ordinates the cut off determined was 48.9.
- The Sternal index with the score of less than or equal to 48.9 could be males and more than the cut off value could be females.

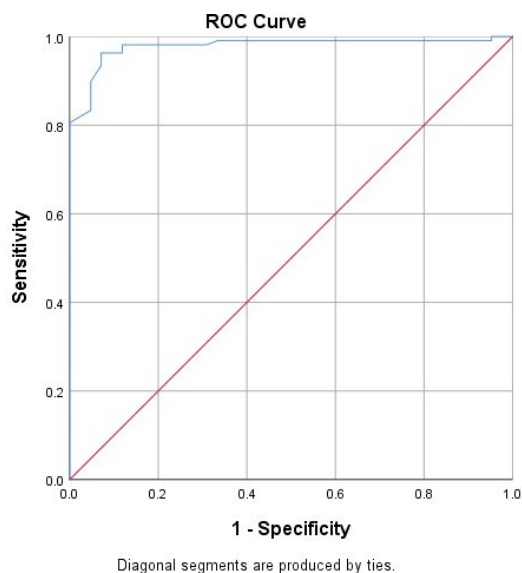


Fig 13: ROC of sternal index for determining the actual sex.

Discussion

The observations presented highlight the consistent trend that most skeletal metrics, with the exception of sternal index, show larger values in males. In all the earlier researches, the sternal index was consistently found to be high in females. The results obtained from this study are in accordance with the above statement^{4,6,7,8,9}.

Males were found to have a substantially longer mean sternum length (11.2 cms) than females (7.67cms). Males have a substantially longer mean total sternum length (16.6cms) than females do (11.6cms). In females, the manubrium is longer than the body of the sternum by more than half, but in males, the body of the sternum is at least twice as long as the manubrium^{1,2,3}.

All previous studies, i.e., a value above which the sternum could be sexed as male and a value below which it could be sexed as female, provide two cut off values for sex determination. No sex-related opinion can be drawn if the value found for a specific sternum falls between these cutoff ranges. It appears clear that it is impossible to determine the sex for those sterna with measurements within these limitations.

Only a clear cutoff value over or below which the sternum can truly be sexed is mentioned in the current study. In order to help with sex identification, this study also offers the mean value for every sternal parameter (sex wise).

Thus, it can be established that a subject may be **male** if the following conditions are present:

1. The sternum's body is longer than 9.3 cms or more.
2. Manubrium length is larger than 4.65 cms or more.
3. The sternal index is 48.9 or less.
4. The overall sternum is longer than 14.25cms or more.

If the following conditions are true, a subject may be **female**:

1. The sternum's body is lesser than 9.3cms.
2. Manubrium length is lesser than 4.6cms.
3. The sternal index is 49 and more.
4. The overall sternum is lesser than 14.25cms.

Length of body of sternum can be taken as the most reliable sternal parameter for determining the sex followed by the total sternal length.

KNOWN LEARNINGS:

1. Sexual Dimorphism in Sternal Measurements

- o Males generally have larger skeletal metrics than females, except for the sternal index, which is higher in females.
- o The sternum's body is significantly longer in males, while in females, the manubrium is relatively longer than the sternum's body.

2. Limitations in Sex Classification

- o If sternal measurements fall within certain intermediate ranges, accurate sex classification remains uncertain.

UNKNOWN LEARNINGS:

1. Confirmation of Sternal Trends in Sexual Dimorphism

- o The study reinforces that males have a significantly longer total sternum and sternum body length, while females have a higher sternal index.
- o It confirms that in females, the manubrium is proportionally longer compared to the body of the sternum, whereas in males, the sternum's body is at least twice as long as the manubrium.

2. Reliability of Sternal Parameters for Sex Determination

- o The length of the sternum's body is identified as the most reliable metric for sex determination, followed by the total sternal length.
- o The study provides mean values for each sternal parameter based on sex, improving the precision of identification.

3. Defined Cutoff Values for Sex Determination

- o Unlike previous studies that acknowledged difficulty in classifying sterna with intermediate measurements, this study establishes clear cutoff values

for sex determination based on sternal parameters.

CONCLUSION

To ascertain a person's sex, the Sterna obtained from 150 documented cases of medicolegal autopsy performed between November 2021 and April 2022 were examined.

The given criteria provide a method for determining the probable biological sex of a subject based on sternal measurements.

Males tend to have a longer sternum body, a longer manubrium, a lower sternal index and an overall greater sternum length. In contrast, females generally have a shorter sternum body, a shorter manubrium, a higher sternal index and a shorter overall sternum length.

Length of body of sternum can be taken as the most reliable sternal parameter for determining the sex followed by the total sternal length.

These measurements can be useful in forensic anthropology and osteological studies for sex determination.

CONFLICT OF INTEREST: NONE DECLARED.

SOURCE OF FUNDING: SELF.

ETHICAL CLEARANCE: ETHICAL COMMITTEE APPROVAL OBTAINED FROM INSTITUTIONAL ETHICAL COMMITTEE, KAPV MEDICAL COLLEGE, TRICHY. Ref no: KAPV/IEC/ 2021/ 022 dated 24.10.2021.

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