Correlation of Sex & BMI with Fusion of Human Sternum in 'Bengalee' Population from Dead Bodies Sent for Autopsy in NRSMCH Morgue

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Abstract

Background: Sternum is the bone which gives a fair idea for the estimation of age in the later decades of life. It is a well established fact that factors like endocrinal, heredity, climate, diatic habits have certain degree of influence over bony union and it is also proved that epiphyseal union occurs one to two years earlier in females than in males. BMI (Body Mass Index) is defined as person's weight in kilograms divided by the square of height in meters. **Methods:** The aim of the study is to establish any Correlation of sex and BMI with the fusion of different parts of Sternum in Bengalees.120 sternums are studied in this study over a period of 1.5 years from the dead bodies of 'Bengalee' persons sent for Post Mortem examination in the Hospital morgue, Department of Forensic Medicine & Toxicology, N.R.S Medical College & Hospital, Kolkata. **Concussion:** There was no significant difference between male and female in respect to the ages showing fusion. When the BMI of the subjects were compared with different grades of fusion between the sternal segments, significant statistical correlation was found between the fusion of sternebrae and the BMI, but fusion of Xiphisternum and Manubrium with Mesosternum did not show any statistically significant correlation. Sexual variation of ages for fusion of sternum was not found in 'Bengalee' population. Nutritional status has a significant effect on the fusion of the sternebrae with each other, but no significant effect on the fusion of xiphisternum and manubrium with body of sternum.

Key words: *Sternum, sex, BMI, Bengalee, nutritional status, bony union*

Introduction

Establishment of Identity is one of the key indications of performing Autopsy on the dead body whose identity was not known or in cases of mutilated dead bodies, fragmentary body remains and from bones. In adults after 25 years of age, secondary changes in dentition, fusion of the sutures of skull, fusion of different parts of sternum, calcification of costochondral junction of fourth rib etc. give an estimation of age. Sternum is the bone which gives a fair idea for the estimation of age in the later decades of life. Study of sternum as an individual parameter for estimation of age and sex has been attempted by many workers. The very first recorded data is by Wenzel(1788) who described the difference in the length of manubrium and mesosternum in both sexes. Other studies that followed were that by Fiegel(1837), Dwight(1890)[1] and Ashley(1956)[2,3.] It is a well established fact that factors like endocrinal, heredity, climate, diatic habits have some certain degree of influence over body union and it is also proved that epiphyseal union occurs one to two years earlier in females than in males. [4] BMI (Body Mass Index) is defined as person's weight in kilograms divided by the square of height in meters. A high BMI could be an indicator of high body fatness. Based on BMI weight status are categorised as: below 18.5- underweight, 18.5 to 24.9- normal, 25.0 to 29.9- overweight and 30.0 to 34.9 is considered as obese and BMI above 35 is marked as extremely obese. In a study by **Tayal I et al.** conducted on 500 sternums of known age and sex obtained from postmortem cases brought in the Mortuary of Government Medical college Amritsar, Punjab, they concluded that the fusion of the different sternal elements takes place in relation to age but is

totally independent of sex of the subject. No relation between the sex and the pattern offusion could be established in their study[5]. In a study by **Gautam R.S et al.**conducted on100 sternum, obtained from the cadavers brought for medico-legal post-mortem examination at Ahmedabad, they concluded that the pattern of fusion of sternal elements has no relation with sex.[6] This study is an attempt to find out any correlation between sex and fusion of Human Sternum and also to establish any correlation between BMI with fusion of human sternum.

Aims and Objectives

Aim of The Study

Correlation of sex and BMI with the fusion of different parts of Sternum in Bengalees .

Objectives of The Study:

1. To study the relation of Sex with fusion of different parts of Sternum.

2. To study the relation of Nutritional status with fusion of different parts of Sternum.

Materials and Methods

1. **STUDY AREA**: Hospital Morgue, Department of Forensic Medicine and Toxicology, N.R.S Medical College & Hospital, Kolkata.

2. **STUDY POPULATION**: Dead bodies of 'Bengalee' persons sent for Post Mortem examination in the Hospital morgue, Department of Forensic Medicine & Toxicology, N.R.S Medical College & Hospital, Kolkata.

3. **STUDY PERIOD**: 10th January 2019 – 31st July 2020.

4. **SAMPLE SIZE**: 120

Inclusion criteria:

Dead bodies sent for post mortem examination in the hospital morgue of N.R.S Medical College & Hospital, with authentic age proof documents and relatives present for furnishing additional information.

Age: Individuals aged between 10 years to 70 years has been chosen. The lower limit has been set as to exclude the minimum age for starting of fusion of sternebrae, and the upper limit has been set to surpass the maximum age for fusion of manubrium and body as per available literature till date[7]. Age has been rounded off in nearest years.

Exclusion criteria:

1. Unknown dead bodies.

2. Dead bodies of persons whose relatives did not give consent for the present study.

3. Fracture and/or any diseased condition of sternum.

4. Dead bodies with known identity but without authentic age proof documents.

5. Dead bodies whose relatives were not present for furnishing the information needed for this study.

6. Cases which did not fulfill the criteria of 'Bengalee'.

STUDY DESIGN: Cross-sectional, observational, morgue-based study.

After taking proper consent from the relatives of the deceased, Sternum was removed from the thoracic cavity. An I-shaped incision over the anterior midline of thorax extending from the sternal notch to the end of the xiphoid process, myocutaneous flaps of the thoracic walls of both sides were reflected. The scalpel blade was introduced vertically in the first intercostal space, cartilage of the upper nine ribs were dissected keeping the blade at a 30 ˚ inclination with the vertical plane, and dissecting close to the costochondral junction of the ribs with the sternum. The sternoclavicular joint was identified by moving the shoulder of the same side, the capsule of the joint was dissected, then the tip of the scalpel blade was introduced vertically into the articulation between the medial end of clavicle and the manubrium sterni and rotated, thus the sternum was separated from its attachments with other bones[8,9]. The sternum was washed once and kept in bath containing 10% solution of Sodium hydroxide. In about two weeks the sternum were completely macerated and cleaned of soft tissues except at some patchy small areas. These

were scraped using a scalpel blade. The sternum was washed, and cleaned with detergent and with help of a brush. The macerated sternum was dried and the status of fusion was observed from the morphology.

The four stages of fusion of human bones as recognised by Stevenson are[10]:

1. **Stage of No union-** Clearly evident hiatus between epiphysis and diaphysis. Saw-tooth like external margins of approximated epiphyseal and diaphyseal margins. Epiphysis completely separates from Diaphysis in the process of maceration leaving a billowy surface.

2. **Stage of Beginning of union-** Superficial hiatus between Epiphysis and Diaphysis replaced by a line. Saw-tooth character of approximating Epiphyseal and Diaphyseal margins is lost. There is obliteration of space between Epiphysis and Diaphysis. If Epiphysis separates from Diaphysis the surface found is smooth.

3. **Stage of Recent union-** Characterised by retention of a fine line of demarcation, although active process of bony union is over. In freshly macerated skeleton it is occasionally seen as a faint reddish coloured line.

4. **Stage of Complete union-** Process of union is complete. No line of demarcation is present.

Statistical Analysis

Data has been categorized into ten age groups from 10 years- 70 years of age, group having an interval of five years, only the last group has an interval of six years. Status of fusion for each sternal segment have been categorized as per age group and sex.

Pearson correlation test was applied to determine significance of correlation between progressive stages of fusion of the sternal segments from Stage 0 to Stage 3 with increasing age from 10 years- 70years for the total 120 study subjects i,e. whether the advanced stages of fusion have any positive correlation with increasing age in all the subjects in this study.

Definitions: 'Bengalee' can be defined as a person who is born and brought up in West Bengal and whose mother tongue is Bengali.

Result and Analysis

Table 1: AGE GROUP & SEX WISE DISTRIBUTION OF THE STUDY POPULATION

AGE(YEARS)	MALE	FEMALE	TOTAL
10-15	2	2	4
16-21	2	4	6
22-27	10	6	16
28-33	6	0	6
34-39	4	8	12
40-45	18	2	20
46-51	18	6	24
52-57	12	0	12
58-63	4	2	6
64-70	8	6	14
TOTAL	84	36	120

The study population has been categorized as per sex into different age groups, which shows, that in the current study: In the study population of 120 subjects in this study, 84 were male and 36 were female.

Table 2: Sex wise Mean BMI in different grades of fusion between third & fourth sternebrae.

3RD& 4TH STERNEBRAE	GRADES OF FUSION			
	UNION RECENTLY COMPLETE (NO. OF CASES)		COMPLETE UNION (NO. OF CASES)	
	MALE	FEMALE	MALE	FEMALE
	2	-	82	36
MEAN BMI	17.6	-	21.29	22.19
STANDARD DEVIATION	0	-	2.94	2.39

Fusion between the third and fourth sternebrae was found in two stages namely stage 2 and Stage 3. Stage 2 fusion was found in 2 male (1.66% of total study subjects) and their mean BMI was 17.6±0. Stage 2 fusion was found in 0 female (0% of total study subjects). Stage 3 fusion was found in 82 male (68.33% of total study subjects) and their mean BMI was 21.29±2.94. Stage 3 fusion was found in 36 female (30% of total study subjects) and their mean BMI was 22.19±2.39.

When Pearson correlation was applied to compare BMI and increasing grades of fusion between third and fourth sternebrae, it showed positive Pearson correlation of 0.180 with a p value of 0.049 which shows significant positive correlation.

Table 3: Sex wise Mean BMI in different grades of fusion between second & third sternebrae.

2ND& 3RD STERNEBRAE	GRADES OF FUSION			
	NO UNION (NO. OF CASES)		COMPLETE UNION (NO. OF CASES)	
	MALE	FEMALE	MALE	FEMALE
	2	-	82	36
MEAN BMI	17.6	-	21.29	22.19
STANDARD DEVIATION	0	-	2.94	2.39

Fusion between the second and third sternebrae was found in two stages namely stage 0 and Stage 3. Stage 0 fusion was found in 2 male (1.66% of total study subjects) and their mean BMI was 17.6±0. Stage 0 fusion was found in 0 female (0% of total study subjects). Stage 3 fusion was found in 82 male (68.33% of total study subjects) and their mean BMI was 21.29±2.94. Stage 3 fusion was found in 36 female (30% of total study subjects) and their mean BMI was 22.19±2.39.

When Pearson correlation was applied to compare BMI and increasing grades of fusion between second and third sternebrae, it showed positive Pearson correlation of 0.180 with a p value of 0.049 which shows significant

positive correlation.

Table 4: Sex wise Mean BMI in different grades of fusion between first & second sternebrae.

1ST& 2ND STERNEBRAE	GRADES OF FUSION					
	NO UNION (NO. OF CASES)		UNION RECENTLY COMPLETE (NO. OF CASES)		COMPLETE UNION (NO. OF CASES)	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
	2	-	2	2	80	34
MEAN BMI	17.6	-	18.4	22.9	21.36	22.15
STANDARD DEVIATION	0	-	0	0	2.94	2.46

Fusion between the first and second sternebrae was found in three stages namely Stage 0, Stage 2 and Stage 3. Stage 0 fusion was found in 2 male (1.66% of total study subjects) and their mean BMI was 17.6±0. Stage 0 fusion was found in 0 female (0% of total study subjects). Stage 2 fusion was found in 2 male (1.66% of total study subjects) and their mean BMI was 18.4±0. Stage 2 fusion was found in 2 female (1.66% of total study subjects) and their mean BMI was 22.9±0. Stage 3 fusion was found in 80 male (66.66% of total study subjects) and their mean BMI was 21.36±2.94. Stage 3 fusion was found in 34 female (28.33% of total study subjects) and their mean BMI was 22.15±2.46.

When Pearson correlation was applied to compare BMI and increasing grades of fusion between first and second sternebrae, it showed positive Pearson correlation of 0.188 with a p value of 0.039 which shows significant positive correlation.

Table 5: Sex wise Mean BMI in different grades of fusion between xiphisternum & mesosternum.

XIPHISTERNUM & MESOSTERNUM	GRADES OF FUSION					
	NO UNION (NO. OF CASES)		BEGINNING OF UNION (NO. OF CASES)		COMPLETE UNION (NO. OF CASES)	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
	44	**18**	**18**	**10**	**22**	**8**
MEAN BMI	21.19	21.76	20.02	22.88	22.18	22.33
STANDARD DEVIATION	3.33	1.85	2.80	2.06	1.85	3.70

Fusion between the xiphisternum and lower end of mesosternum was found in three stages namely Stage 0, Stage 1 and Stage 3. Stage 0 fusion was found in 44 male (36.66% of total study subjects) and their mean BMI was 21.19±3.33. Stage 0 fusion was found in 18 female (15% of total study subjects) and their mean BMI was 21.76±1.85. Stage 1 fusion was found in 18 male (15% of total study subjects) and their mean BMI was 20.02±2.80. Stage 1 fusion was found in 10 female (8.33% of total study subjects) and their mean BMI was 22.88±2.06. Stage 3 fusion was found in 22 male (18.33% of total study subjects) and their mean BMI was 22.18±1.85. Stage 3 fusion was found in 8 female (6.66% of total study subjects) and their mean BMI was 22.33±3.70.

· When Pearson correlation was applied to compare BMI and increasing grades of fusion between xiphisternum and mesosternum, it showed positive Pearson correlation of 0.126 with a p value of 0.171 which does not show significant correlation.

Table 6: Comparison between BMI and increasing grades of fusion between manubrium & mesosternum

Increasing grades of fusion between manubrium & mesosternum N=120		BMI
	Pearson Correlation	-0.146
	Sig. (2-tailed)	0.111

When Pearson correlation was applied to compare BMI and increasing grades of fusion between manubrium and mesosternum, it showed negative Pearson correlation of -0.146 with a p value of 0.111 which does not show significant correlation.

Discussion

Mean BMI of both sexes were compared with increasing grades of fusion for all the sternal segments which are represented as follows:

1. Increasing grades of fusion between third and fourth sternebrae for both sexes was compared with mean BMI which is tabulated in Table 2. When statistically compared a significant p value was obtained which is shown in Table 3.

2. Increasing grades of fusion between second and third sternebrae for both sexes was compared with mean BMI which is tabulated in Table 4. When statistically compared a significant p value was obtained which is shown in Table 5.

3. Increasing grades of fusion between first and second sternebrae for both sexes was compared with mean BMI which is tabulated in Table 6. When statistically compared a significant p value was obtained which is shown in Table 7.

4. Increasing grades of fusion between xiphisternum and mesosternum for both sexes was compared with mean BMI which is tabulated in Table 8. When statistically compared p value obtained was not significant which is shown in Table 9.

5. Increasing grades of fusion between manubrium and mesosternum for both sexes was compared with mean BMI and when statistically compared p value obtained was not significant which is shown in Table 10.

Conclussion

There was no significant difference between male and female in respect to the ages showing fusion.

When the BMI of the subjects were compared with different grades of fusion between the sternal segments, significant statistical correlation was found between the fusion of sternebrae and the BMI, but fusion of Xiphisternum and Manubrium with Mesosternum did not show any statistically significant correlation.

Sexual variation of ages for fusion of sternum was not found in ‘Bengalee’ population. Nutritional status

has a significant effect on the fusion of the sternebrae with each other, but no significant effect on the fusion of xiphisternum and manubrium with body of sternum.

Limitations of The Study

Despite all sincere efforts the present study has some lacunae. To name some notable shortcomings:

1. The sample size was only 120, a larger sample size would have yielded more outcomes which when analysed statistically would have given more significant results. Cause of limited sample size was limited time period of the present study, and exclusion criteria.

2. There was no female study subjects in 28 years- 33 years and 52 years- 57 years age groups due to shortage of female subjects which were brought to the morgue for autopsy in these age groups and also due to the criteria for exclusion.

3. Equal representation of male and female in each age group was not possible, which would have been a better standard for comparison in the present study.

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Ø **Ethical Clearance:** Taken from Institutional Ethics Committee of NRSMCH

Ø **Conflict of Interest:** None

References

1. Dwight T. Irregular Union of the First and Second Pieces of the Sternum in Man and Apes. J Anat Physiol. 1890; 24(4):536–42.
2. Gautam RS, Shah GV, Jadav HR, Gohil BJ. The Human Sternum – as An Index of Age & Sex. J Anat Soc India. 2003; 52(1):20-3.
3. Ashley GT. The relationship between the pattern of ossification and the definitive shape of the mesosternum in man. J Anat. 1956; 90(1):87–105.
4. Karmakar RN. Forensic Medicine and Toxicology. 5th ed. Kolkata: Academic Publisher; 2015. p. 29.
5. Tayal I, Rai G, Gargi J, Chanana A. Medico-legal importance of sternum in age estimation-an Autopsy study. J Punjab Acad Forensic Med Toxicol. 2013;13(2):80-5.
6. . Gautam RS, Shah GV, Jadav HR, Gohil BJ. The Human Sternum – as An Index of Age & Sex. J Anat Soc India. 2003; 52(1):20-3.
7. Aggrawal A. Textbook of Forensic Medicine and Toxicology. 1st ed. Delhi: Avichal Publishing Company; 2014 (reprint 2017). p. 82.
8. Reddy KSN, Murty OP. The Essentials of Forensic Medicine & Toxicology. 34th ed. New Delhi: Jaypee Brothers; 2017. p. 63,71,104.
9. Saphir O. Autopsy Diagnosis and Technic. 3rd ed. New York: Paul B. Hoeber Inc; 1951. p. 79-85
10. Das SK. Is ossification of sternum at all a valuable guide for determination of age at middle age group?. JIAFM. 2005; 27(1):31-3.