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Original Research Article

STERNUM AS AN INDEX FOR DETERMINATION OF SEX

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ABSTRACT

Background: To examine human bones is a challenge for experts, especially in deceased and also for determination of sex for medico-legal purpose. Measurement of the sternum is done by many authors for determination of sex. Sternum was measured for length of manubrium, length of mesosternum and combined length of manubrium and mesosternum. The data was statistically analysed.

Method: The present study was done on 65 human sternums(46 Males and 19 Females). Sternum was extracted from cadavers in the Department of Anatomy, People's College of Medical Sciences and Research Centre, Bhopal and Sternum from Autopsy bodies in the Department of Forensic Medicine and Toxicology, People's College of Medical Sciences and Research Centre, Bhopal. (MP),India.

Results: If the combined length of a sternum is less than 150 mm then it is of female sternum, if it exceeds 150 mm, it is of male sternum. The mean Sternal Index in male was 43.43 and in females 41.132. 89.13% of male and 21.05% of female specimen obey the Hyrtl's law.

Conclusion: The combined length of manubrium and mesosternum is considered as the most important parameter, which when applied to an individual specimen can help in sexing the sterna correctly in our study.

KEY WORDS: Manubrium sterni, Mesosternum or Body of sternum, Sternal angle, Sternal Index.

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INTRODUCTION

Lot of work has been done and ample literature is available in anatomy and anthropology for identification of human skeleton. For medico-legal purposes, examination of human skeleton is a important part. To know whether the bone is of male or the female from unknown human skeletal or decomposed bodies is an important step in forensic investigation and also to know correct age and sex of specimen. If whole skeleton is available for examination, we can identify the sex(male/ female) with 100% accuracy. When only skull or pelvis is available, sex can be determined with 90% accuracy. If no skull and pelvis is available, it becomes difficult to know the age and sex accurately[1]. To know 100% accuracy in determining the sex, it depends on the nature of material available and methods applied.

Measurement of human sternum as an individual parameter for determination of age and sex has been done by many workers. Wenzel (1788) recorded data for the first time. He concludes that the difference in the ratio between the length of manubrium and that of mesosternum in both sexes. Following him, further studies done by Fiegel (1837), Dwight (1890), and Ashley (1956). In the present study, length of manubrium, length of mesosternum and combined length of manubrium and mesosternum

were measured and determination of sex done by human sternum.

The osseous skeleton of sternum is the only structure which resists the effect of putrefaction and decomposition for longer time. The ratio between manubrial and mesosternal lengths differs in the males and female sternum. Sternum is useful for determination of sex of an individual. Studies done on human sternum reported in both sexes of American, African and European population and also in different zones of Indian population like North Indian, Maharashtra and Gujarati population. Ashley (1956) [2] studied the combined length of manubrium and body of sternum in both male and female in European population. He forwarded "rule of 149", if the combined length of manubrium and mesosternum is more than 149 mm then sternum of male and if less than 149 mm, then sternum was female but it is not applicable for African population, so new rule of "136"(1956) [2] for African Population.

Sternum: The sternum consists of a cranial manubrium (prosternum), an intermediate body (mesosternum), and a caudal xiphoid process or xiphisternum (metasternum). The mesosternum consists of four sternebrae, from its costal relations. The length of the male sternum is 17cm and less in female sternum. The ratio between manubrial and mesosternal lengths differs between the two sexes. Growth may continue beyond the third decade and possibly throughout life.

In natural stance, the sternum slopes down and slightly forwards. It is convex in front, concave behind, and broadest at the junction with the first costal cartilages. It is narrowest at the manubriosternal joint, andnarrows below the fifth cartilages . The sternum has highly vascular trabecular bone enclosed by a compact layer which is thickest in the manubrium . The medulla contains red bone marrow.

MATERIALS AND METHODS

Human Sternum from cadavers in the Department of Anatomy and Sternum from Autopsy bodies which were brought for medico-legal post- mortem examination in the Department of Forensic Medicine and Toxicology, People's College of Medical Sciences and Research Centre, Bhopal, (MP), (From February 2014 to August 2015).

All the sternum to be examined with inclusion criteria, which came for autopsy and those of dissection cadavers have been included in the study.

Fig. 1: Vernier Caliper.

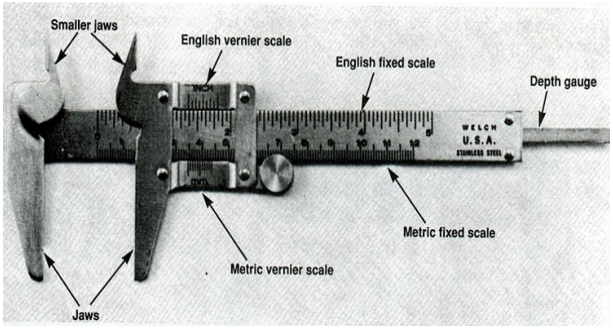
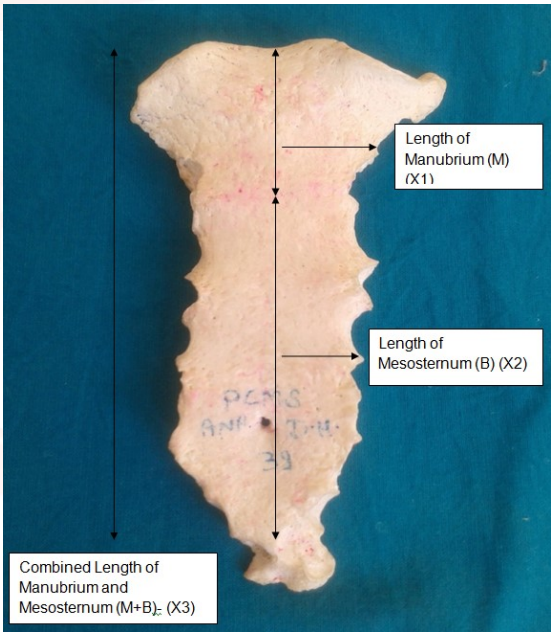


Fig. 2: Measurements of Sternum X1, X2, X3.



Study material –Human Sternum

Study sample - 65 sternums(46 Males and 19 Females)

Technique - The sterna were removed from the cadavers by sectioning the costal cartilages just beside the costo-chondral junction.

Inclusion Criteria – Sterna without any obvious pathology above the age of 10 years.

Exclusion Criteria - Deformed sternum, Diseased sternum and Fractured sternum.

Measurements were taken in millimetres, with the help of Vernier Caliper-

1. Length of manubrium (M) - It is the distance from suprasternal notch to Manubriomesosternal junction in midline. (X1)

2. Length of mesosternum (B) - It is the distance from manubrio-mesosternal junction to the mesosterno-xiphoidal junction in the midline. (X2)

3. Combined length of manubrium and mesosternum = M + B (X3)

4. Manubrio-corpus index (X6) = Length of manubrium (M) / Length of mesosternum (B) x 100

Instrument used - Vernier Caliper

The vernier caliper is a slide-type calliper used to take inside, outside, and depth measurements. The vernier caliper has two metric scales and two English scales.

RESULTS

Length of Manubrium: The present study indicate that the difference between the average length of male and female manubria is 3.26 mm ,which is statistically not significant (p= 0.07), thus the measurement of Length of Manubrium is least helpful for sexing sternum.

Length of Mesosternum: In present study, the average difference in the length of (Body of sternum)mesosternum between the male and female sternum is 2.4 mm which is statistically significant (p=0.001), the length of mesosternum is useful in determining the sex of sterna, because the length of mesosternum is more than the length of manubrium in male sternum.

Combined Length of the manubrium and Mesosternum: In our study, the difference between the average combined length of manubrium and mesosternum in male and female sternum is 5.407 mm which is statistically significant(p=0.001). The co-extensive range is 153.087-147.087 mm, is very useful in determination of sex of sternum.

All the above observations are given in Table number 1

Manubrio – Corpus index (Sternal Index): Mean sternal index difference in male sternum and female sternum was 2.306. In the present study, 21.05% female and 89.13% male specimens obey the Hyrtl's law. p value 0.8, which is not significant, this law is not helpful in determining the sex.

Discriminant Function Analysis Results: To define classification of the bones and to discriminate between sexes of the sterna, Fischer's Discriminant to all metric observations of all the paramaters , two variables can identify the sex category of the studied bones. The discrimination method was based on Wilk's lamda criteria.

The discriminate analysis done by given formula –

D = (2.348 x Manubrium length) + (2.697 x Mesosternal length) + (- 3.302 x Combined length of manubrium and mesosternum)

Centroid of cut off taken as

$$-\frac{0.149 + (-0.361)}{2} = (-0.106)$$

When D is more than -0.106, it is male sternum

When D is less than -0.106, it is female sternum

61.5% were classified correctly.

Sensitivity	–	56.5%
Specificity	–	73.7%
Positive Predicted Value	–	83.87%
Negative Predicted Value	–	41.17%

OBSERVATIONS

Fig. 3: Length of Manubrium (M)-(X1).

Fig. 3: Length of Manubrium (M)-(X1).

Table 1: Various measurements of the sterna in the Males and Females.

Parameter	Sex	Range	Mean	SD	t test	Level of significance for difference between the means (p value)	No & % of cases within overlapping zone
Length of manubrium (M) (X1)	M	34-60	46.26	6.8164337	0.0788	0.07(not significant)	8(17.39%)
	F	32-54	43	6.377			14(73.68%)
Length of mesosternum (B) (X2)	M	86-127	107.08	11.378	2.1845	0.001 (significant)	10(21.73%)
	F	69-125	104.68	13.258			13(68.42%)
Combined length of manubrium and mesosternum = M + B(X3)	M	123-179	153.087	14.972	1.08E-39	0.001 (significant)	18(39.13%)
	F	101-167	147.68	15.62			8(42.10%)
Manubrio-corpus index (X6)	M	31.4-60	43.43	6.5031	0.8046	0.8(not significant)	3(6.5%)
	F	32.2-52.63	41.132	7.1807			3(15.78%)

Table 2: Statistical Analysis of sterna of both sexes.

	Male Sternum	Female Sternum	P value (level of significance)
Actual sample	46	19	
By Hyrtl's law	41	4	0.8 (not significant)
No. and % of specimen obeying Hyrtl's Law	41(89.130%)	4(21.05%)	

Table 3: Showing age group wise and sex wise distribution of total cases.

Group	I	II	III	IV	V	VI	VII
Age(yrs)	Oct-20	20-30	30-40	40-50	50-60	60-70	70-80
Male Sternum	11	13	11	3	5	2	1
Female Sternum	4	6	4	3	0	1	1
Total	15	19	15	6	5	3	2

Table 4: Combined length of the sternum in male and female.

Male Sternum		Female Sternum	
Interval of sternum (mm)	Frequency	Interval of sternum (mm)	Frequency
110-119	0	100-109	1
120-129	4	110-119	0
130-139	7	120-129	1
140-149	7	130-139	2
150-159	9	140-149	7
160-169	13	150-159	4
170-179	6	160-169	4
Total	46	Total	19

Table 5: Showing Interval of Sternal Index in Males and Females.

S. no	Interval of Sternal Index	Male Sternum	Female Sternum
1	30-35	6	5
2	36-40	8	5
3	41-45	12	3
4	46-50	17	3
5	51-55	1	3
6	56-60	2	0
	Total	46	19

DISCUSSION

The measurement of sternum done by many authors, regarding the sexual differences in the length of manubrium, mesosternum and combined length of manubrium and mesosternum are given in the table no 6.

Length of the Manubrium: The present study ,we observe that although the difference between the average length of male and female manubria is 3.26 mm which is statistically not significant (p-0.07), this parameter is not so helpful for sexing the sternum, because in this study 73.68% cases lie in overlapping zone. This is in accordance with Ashley(1956) [2] and Jit et al(1980) [4]. Dwight(1890) observed that the variations in the length of manubrium in two sexes to be very small.

Length of the Mesosternum: In the present study, the average difference in the length of mesosternum between male and female is 2.4 mm which is statistically significant (p-0.001). The length of mesosternum is extremely useful in determining the sex of sterna because the length of mesosternum is twice or more the length of manubrium in both sexes. These findings are co-related with Ashley (1956) [2] and Jit et al (1980) [4].

Combined Length of manubrium and Mesoternum: Ashley (1956) [2] concluded that the average combined length (M+B) in European sterna to be 156.9 mm in males and 138.7 mm in females, giving a difference of 18.2 mm. He observed that a combined length of 149 mm was the dividing line between the male sternum and female sternum. As per Ashley ''The 149 rule', was applicable to 76.7% male and 80.4% female European sterna. Similarly for East Africans he derived ''The 136 rule'' was applicable

Table 6: Sexual Differences by various workers in the lengths of the manubria, mesosterna & combined lengths of manubria & Mesosternum.

				Manubrium(M)		Mesosternum(B)		Manubrium + Mesosternum(M+B)	
S No	Authors	Sex M-Male F-Female	No of specimen	Mean Length (mm)	Diff Length in mean	Mean Length (mm)	Diff Length in mean	Mean Length (mm)	Diff Length in mean
1	Dwight (1881)	M F	30 26	51.8 46.7	5.1	105.9 89.4	16.5	- -	- -
2	Strauch (1881)	M F	200 -	- -	-	110 90	20	- -	- -
3	Dwight (1890)	M F	142 86	53.7 49.4	4.3	110.4 91.9	18.5	164.1 141.3	22.8
4	Paterson (1904)	M F	310 126	52 47.3	4.7	103.7 91	12.7	- -	- -
5	Ashley African (1956)	M F	85 13	45.9 44.2	1.7	96.5 82.9	13.6	142.6 127.1	15.5
6	Ashley European (1956)	M F	378 168	52.2 47.9	4.3	104.7 90.8	13.9	158.9 138.7	18.2
7	Jit etal (1980)	M F	312 88	51.73 48.42	3.31	95.35 78.6	16.75	147.08 127.02	20.06
8	Dahipale et al (2002)	M F	96 47	48.42 43.78	4.64	94.43 70.19	24.23	142.2 113.87	29.32
9	Gautam et al (2003)	M F	56 44	53 48	5	95 76	19	149 124	25
10	Mahajan et al(2009)	M F	98 55	57.86 46.96	10.9	115.19 93.85	21.34	173.05 140.82	32.23
11	Puttabanthi et al(2012)	M F	57 22	47.48 21.68	25.8	92.36 88.95	3.41	139.55 110.64	28.91
12	Present study 2015	M F	46 19	46.26 43	3.26	107.08 104.68	2.4	153.087 147.68	5.407

to 77.6% male and 84.6% female sterna.

He shows that coextensive range of the two sexes in European sterna extends from 126 mm to 171 mm.. The co-extensive range covered 341 out of 378 male (90.2%) and 153 out of 160 female (91.1%) sterna. Jit et al (1980) [4] observed that the combined length is extremely useful in determining the sex of North Indian sterna. The average difference between the means is 20.06 mm which is statistically highly significant (P<0.001). They also applied ''the 136 rule'', given by Ashley (1956) [2]. By which they determined the sex of 86% male and 78% female sterna. In our study, the difference between the average combined lengthof sternum is 5.407 mm which is statistically highly significant. The co-extensive range is 114-144 mm and by halving the same, we can come to ''The 129 rule'', similar to that given by Ashley (1956) [2]. By this rule 91.66% male and 82.97% female sterna can be identified correctly. In present study, the average combined length of manubrium and mesoaternum was 153.087 mm in males and 147.68 mm in females.

Measurements by various workers in the lengths of the manubria, mesosterna & combined lengths of manubria & mesosternum in males and females, given in table number 1.

Manubrio – Corpus index (Sternal Index): Wenzel (1788) concluded that the length of manubrium in male sternum and female sternum, is almost equal in length, but the mesosternum is longer in male sternum.. This led to enunciation of Hyrtl's law, according to which manubrio corpus index (sternal index) exceeds 50 in female sternum and is less than 50 in male sternum. Table No. 2 gives the percentage of cases obeying the Hyrtl's law in

male sternum and female sternum.. In the present study, 21.05% female and 89.13% male specimens obey the Hyrtl's law. P value 0.8, is not significant, this law is not helpful in determining the sex.

Ashley (1956) [2] and Jit et al (1980) [4] both concludes that the Hyrtl's law to be 'unreliable.'

Table 7: Ability of Hyrtl's Law (M/B x 100 = <50 male sternum, >50 female sternum).

Observer	Year	Number of specimen	Sex M –Male F - Female	% Obeying law
Dwight	1890	142	M	59.10%
		86	F	60.40%
Patermoller	1890	55	M	65%
		33	F	-
Krause	1897	-	M	-
		14	F	43%
Ashley African	1956	85	M	64.70%
		13	F	69.20%
Ashley European	1956	378	M	52.90%
		171	F	69.30%
Narayan & Verma	1958	126	M	34.12%
		27	F	81.48%
Jit etal	1980	312	M	31.08%
		88	F	88.64%
Dahipale et al	2002	96	M	52.20%
		47	F	100%
Atal et al.	2008	56	M	
		44	F	75%
Puttabanthi et al.	2012	57	M	94.73%
		22	F	4.54%
Present study	2015	**46**	**M**	**89.13%**
		19	**F**	**21.05%**

Discriminant Function Analysis: In the present study, we subjected our data to multivariate discriminant analysis technique as given by Armitage (1971) and by this method 61.5% were classified correctly sterna can be sexed correctly. Penrose (1947) and Jit et al (1980) [4] by multivariate analysis , they observed 89% male and 82% female sterna could be sexed correctly.

Dahiphale V P, Baheete B H, Kamkhedkar S G. (2002), observed that the length of mesosternum (B) distinguishes 69.80% male sternum and 76.60% female sterna and with the combined length of manubrium and mesosternum (M+B) 38.54% male and 57.45% female sterna can be sexed correctly. By applying the multivariate linear discriminant analysis technique 92% male and 87% female sterna can be sexed correctly. If the length of mesosternum was more than 88 mm, the sternum was male and if less than 76mm, it was female sternum. By its measurement 69.80% male and 76.60% female sterna could be sexed.

The combined length of manubrium and mesosternum could also determine the sex correctly in 38.54% male and 57.45% female specimens [5].

In present study, the length of mesosternum (B) distinguishes 78.26% male sternum and 31.57% female sternum and with the combined length of manubrium and mesosternum (M+B) 60.86% male and 57.89% female sterna can be sexed correctly. By applying the multivariate linear discriminant analysis technique 61.5% were classified correctly sterna can be sexed correctly. If the length of mesosternum was more than 100 mm, the sternum was male and if less than 100 mm, it was female.

But overlapping zone in both sexes(21.73% males and 68.42 % females). The combined length of manubrium and mesosternum could also determine the sex correctly in 60.86% male and 57.89% female specimens.

Gautam R S, Shah G V, Jadav H R, Gohil B J(2003) they concluded that the length of manubrium, it is in the range of 35 mm to 70 mm in male sternum and 40 mm to 61mm in female sternum. The mean length of manubrium is 53 mm in males and 44 mm in females. The combined length of manubrium & body of sternum ranges from 101 mm to 192 mm in male and 98 mm to150 mm in female. The combined mean length of manubrium and mesosternum was 149 mm in male and 124 mm in females. If the length of the manubrium is less then 33 mm then it is of a female sternum, if it is above 63 mm it is of a male sternum. If the length of the body of sternum is less than 48 mm then it is of female sternum, if it is more than 106 mm then it is male sternum . If the combined length of a sternum is less than 92 mm then it is of female sternum where as if it exceeds 161 mm, it is of male sternum [1].

In present study, the combined length of manubrium & body of sternum ranges from 123 mm to 179 mm in male sternum and 101 mm to 167 mm in female sternum. The combined mean length of manubrium and mesosternum was 153.043 mm in male sternum and 147.68 mm in female sternum.

If the length of the manubrium is less then

Table 8: Mean length of various parts of sternum.

S. No	Worker	Sex	No of specimen	Length of manubrium (mm)	Length of mesosternum (mm)	Combined length (mm)
1	Dwight (1881)	M	30	51.8	105.9	157.7
		F	26	46.7	89.4	136.1
2	Dwight (1890)	M	142	53.7	110.4	164.1
		F	86	49.4	91.9	141.3
3	Ashley (1956)	M	85	45.9	96.5	142.6
		F	13	44.2	82.9	127.1
4	Jit (1986)	M	312	51.73	95.35	147.08
		F	88	48.42	78.6	127.02
5	Present study	M	**46**	**46.26**	**107.08**	**153.087**
		F	**19**	**43**	**104.68**	**147.68**

40 mm then it is of a female sternum. If it is exceeds 40 mm it is of a male sternum. If the length of the body of sternum is less than 100 mm then it is of female, if it is more than 100mm then it is male. If the combined length of a sternum is less than 150mm then it is of female where as if it exceeds 150mm, it is of male. Table no 3 shows Mean length of various parts of sternum in different authors studies with the present study.

Robert Selthofer, Vasilije Nikoli, and etal(2006), Morphometric analyses showed that the proportional sternum structure in the females and in the males is equal. Indexes of manubrium length proportion as well as of body of the sternum length proportion are almost identical in sterni of both sexes. There is no statistical significance in sternal angle value [6]. Our study shows same observations.

D K. Atal, A. Murari etal(2008) they observed that sternal index was not reliable in sex determination. The mean sternal index for male was 46.089 and female was 56.703. The level of significance of the difference between the means was statistically highly significant ($p< 0.001$) for sternal index. Out of 56 males sternums, 34 male cases (60.71%) were lying in overlapping zone while of the 44 female cases, 40 cases (90.91%) were lying in overlapping zone. Only 22 male and 4 female cases were not lying in the overlapping zone 89.28% male and 75.00% female specimens obey the Hyrtl's Law [7].

In present study, the mean sternal index for male was 43.43 and female was 41.132. Jagmahender Singh, Dalbir Singh, RK(2010) they observed that the combined length of manubrium and mesosternum is the reliable and useful estimator of sex in human sternal measurement. The mean length of manubrium for male sternum was 52.1 mm and of female sternum was 47.17 mm. The difference between means of male and female manubrial length was 7.79 which was statistically high ($p<0.0001$), on the basis of this only 12.3% males and 16.48% females were identified. Mean mesosternal length in males was 94.07 mm and in females sternum it was 78.54 mm, the difference in the means for length of mesosternum of two sexes was found to be 12.49, which was highly significant. The combined length of manubrium and mesosternum for male sterna was 145.69 mm and for female was 124.87 mm. Sternal index of male sternum was 56.13 and for female was 61.23 mm [8].

In present study, the mean length of manubrium for male sternum was 46.26 mm and of female sternum was 43 mm. The difference between means of male and female manubrial length was 3.26, statistically significant 82.6% males and 26.31% females were identified. Mean mesosternal length in males was 107.08 mm whereas in females sternum it was 104.68 mm, the difference in the means for length of mesosternum of two sexes was 2.4, which was significant. The combined length of manubrium and mesosternum for male sterna was 153.087 mm and for female was 147.68 mm. Sternal index of male sternum was 43.43 and for female was 41.132 mm.

Osunwoke E.A, Gwunireama I.U (2010) they found that average mean length of male and female manubrium was 60.7± 10.7mm and 46.0 ±6.13mm, respectively. The average mean length of the male and female mesosternum was

101.3 ±13.22 mm and 77.9 ± 7.07 mm, respectively. The combined length of the manubrium and mesosternum for male and females was 164.6 ± 19.96 mm and 123.3 ± 11.8 mm, respectively. The length of the mesosternum distinguishes 89.70% males and 61.5% females while the combined length of the manubrium and mesosternum distinguished 94.11% males and 9.23% females, detects sex correctly. The length of the manubrium was not useful in sexual dimorphism of the Sternum [9].

In present study, that average mean length of male and female manubrium was 46.26 mm and 43 mm respectively. The average mean length of the male and female mesosternum was 107.08 mm and 104.68 mm respectively. The combined length of the manubrium and mesosternum for male and females was 153.087 mm and 147.68 mm, respectively. With combined length 61.5% sternum were classified correctly.

Sirisha Puttabanthi, Dr. Subhadra Devi Velichety(2012), according to them length of manubrium may act as a good discriminator of female sterna as it is showing 100% of accuracy. Combined mean length of manubrium and mesosternum acts as a best discriminator to sex unknown sterna. By application of binary logistic multivariate discriminant analysis technique 95% male and 45% female sterna can be sexed correctly [10].

Adhvaryu Ankit V, Adhvaryu Monika (2013) they found that if the length of manubrium was less than 39.61mm then it was of female sternum and if it was more than 53.30 mm then it was of male sternum. If the length of mesosternum was less than 67.78 mm then it was of female and if it was more than 94.20 mm then it was of male. If the combined length of manubrium and mesosternum was less than 107.39 mm then it was of female sternum and if it was more than 143.69 mm then it was of male sternum. “The Rule of 136” given by Ashley (1956) was applied to determine the sex of sterna and to determine the number of male and female sterna obeying the rule. Statistically significant difference in mean values of length of manubrium, length of mesosternum and combined length of both sexes was observed. “Rule of 136” determined 34 male sternum and 66 female sterna, while 71.11% (32) of male sterna and 96.34% (53) of female sterna obeyed the rule. They concluded combined length of manubrium and mesosternum was the best discriminating parameter of sex and Rule of 136 was helpful in determination of sex [11].

In present study, If the length of manubrium was less than 40 mm then it was of female sternum and if it was more than 40 mm then it was of male sternum . If the length of mesosternum was less than 100 mm then it was of female sternum and if it was more than 100 mm then it was of male sternum. If the combined length of manubrium and mesosternum was less than 150 mm then it was of female sternum and if it was more than 150 mm then it was of male sternum. Adhvaryu Ankit V, Adhvaryu Monika A(2013) observed that the mean sternal index in male sternum and female sternum were 53.68 and 56.91 respectively. The difference in mean of sternal index in two sexes was 3.23 which was statistically significant ($p<0.05$). It was also observed that 31.11% male (14) and 81.81% female (45) specimens obeyed the Hyrtl’s law which was similar with findings of Narayan and Verma (1958) and Jit et al.(1980). On applying chi-square test, p value was less than 0.008. On applying Hyrtl’s law to the sample, it gave 24 male sternum and 76 female sternum while the actual sample size was 45 male and 55 female. On applying chi-square test it was found that $p<0.002$, which indicated that this difference in observation was highly significant and this law was not helpful in determining the sex of an individual specimen [11].

In present study, the mean sternal index for male sternum and female sternum were 43.43 and 41.132 respectively. The difference in mean of sternal index in two sexes was 2.298 which was not statistically significant (p-0.8).

Kaneriya D, Suthar K(2013) they found that the lengths of the manubrium in the male sterna vary from 35 mm to 71 mm. The Mean was calculated and found to be 52 mm. The Standard Deviation (S.D.) for the length of the manubrium for males is ± 8. The lengths of manubrium in the female sterna vary in the range of 41 mm to 61 mm. The Mean is 48 mm and the S.D. is ± 5. The lengths of the body in male sterna were in the range of 59 - 133 mm. The Mean is 98 mm and S.D. ± 18. The lengths of

the body in female sterna were in the range of 56 - 96 mm. The combined lengths (M+B) in the male cases are in the range from 101-191 mm. The combined lengths in the female cases are in the range from 98 -150mm ,the sternal indices for males are in range of 38 – 77 mm while the female cases are in the range 46 – 78 mm [12].

In present study, the lengths of the manubrium in the male sterna vary from 34 mm to 60 mm and the Mean was 46.26 mm. The Standard Deviation (S.D.) for the length of the manubrium for males is 6.8164337. The lengths of manubrium in the female sterna vary in the range of 32 mm to 54 mm. and Mean is 43 mm and the S.D. is 6.377. The lengths of the body in male sterna were in the range of 86 - 127 mm. The Mean is 107.08 mm and S.D. 11.37800234. The lengths of the body in female sterna were in the range of 69 - 125 mm. The mean was 104.68 and SD – 13.258. The combined lengths (M+B) in the male cases are in the range from 123-179 mm. the mean was 153.087 and SD was 14.972. The combined lengths in the female cases are in the range from 101 –167 mm. the mean was 147.68 and SD was 15.62. The sternal indices for males are in range of 31.4-60 mm, mean was 43.43 and SD was 6.5, while the female cases are in the range 32.2 – 52.63 mm, mean was 41.132 and SD was 7.18.

Mohit V Changani, Jatin Chudasama etal (2014) they concluded that for males, sternal area was found to be most accurate criterion to identify sex by the method of identification point. By using this criterion, 59.64% specimens were correctly identified as male, whereas 17.54% specimens were correctly identified by using the sternal width. Overall, 40.35% specimens were falling in the overlapping zone for the sternal area, which is suggestive of the higher accuracy of the criteria for the determination of sex[13].

CONCLUSION

The present study concluded that the combined length of manubrium and mesosternum is the most reliable criteria for determination of the sex of a sternum out of all the paramaters, with combined length of sternum 61.5% were classified correctly.

By applying the multivariant linear discriminant analysis(D) technique: When D is more than –0.106, it is male sternum, when D is less than -0.106, it is female sternum. 61.5% were classified correctly.

Sensitivity	–	56.5%
Specificity	–	73.7%
Positive Predicted Value	–	83.87%
Negative Predicted Value	–	41.17%

If the length of the manubrium is less than 40 mm then it is of a female. It is exceeds 40 mm it is of a male. But 17.39% males and 73.68 % females are in overlapping zone.

If the length of the mesosternum is less than 100 mm then it is of female sternum, if it is more than 100 mm then it is male sternum. But 21.73% males and 68.42 % females are in overlapping zone.

If the combined length of a sternum is less than 150 mm then it is of female sternum where as if it exceeds 150 mm, it is of male sternum. But 39.13% male sternum and 42.1 % female sternum are in overlapping zone.

Sternal index was also found to be unreliable in sex determination. The mean Sternal Index in male sternum was 43.43 and in female sternum 41.132. 89.13% of male and 21.05% of female specimen obey the Hyrtl's law.

The present study concludes:

1. Length of manubrium may act as a good discriminator of female sterna.

2. Combined mean length of manubrium and body of the sternum acts as a best discriminator to sex unknown sterna.

3. By application of binary logistic multivariate discriminant analysis technique 95% male and 45% female sterna can be sexed correctly.

Out of all the parameters of sterna, combined length of manubrium and mesosternum is the most important parameter which when applied to an individual specimen can help in sexing the sterna correctly in our study.

Conflicts of Interests: **None**

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