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SEX DETERMINATION FROM MEASUREMENTS OF THE STERNUM USING MULTISLICE COMPUTED TOMOGRAPHY OF THE CHEST IN PASHTUN POPULATION OF SWAT

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Abstract
This study was designed, for the first time, to discuss sexual dimorphism in the sternum bone of a specific Pathan race of District Swat, Khyber Pakhtunkhwa. It is hypothesized that the osteometric traits of the sternum will be sexually dimorphic in the peoples of District Swat. The target population was among the patients who came to Radiology Department Saidu Teaching Hospital, Swat for routine investigations with multi-slice computed tomography for chest problems. The population included in the study were, adults aged ranged from 20 to 60 years old, and had no chest wall pathology. A total of 260 (130 each male and female) patients were selected. The parameters studied were sternal area, manubrium length, sternal length, manubrium width and sternal width at two levels. There was a significant difference in the sternum of males than that of females in the Pashtun population of Swat. All the measurements were significantly lower (p <0.001) in female as compared to the male population. The most important prediction of gender is manubrium length, manubrium width and body length. These were the most useful dimensions of the sternum to discriminate genders. In other words, due to the significant differences in the dimensions of the sternum in various ethnicities, gender differentiation is possible by examining all studied parameters.
Keywords: *Sternum, Male, Female, Sexual dimorphism, Pathan, Swat*

INTRODUCTION

Anthropometric investigations of the skeletal elements had provided significant data for species and sex identifications. In forensic studies, pelvic and craniofacial anatomic measurements are commonly used in situations of the absence or destruction of skeletal remains. Several natural and artificial factors like detonations, decomposition, traumatic damage, and environmental factors may affect the availability of the skeletal parts (1, 2), these different factors may deter the inquiries of the pelvic and skull bones. Also, some scientists had stated that the pelvic and skull bones are, in fact, less dependable for sex assessment, however, the identity of the sternum may be retained even in progressive skeletal deformities (3). The sternum is the front bone of the chest. Due to the difference in physical activity and hormonal fluctuation in both genders, the appearances, as well as the morphometric measurements of the sternum, are different in both genders (4). Many studies have been shown differences in the measurements of sternal bone. It is suggested by many researchers that the sternal bone can be used for gender identification and forensic investigations (5-7). Anatomic measurements of different bones directly from human boney remains or radiological investigations are the fundamental anthropological choices for sex estimation (8). Trauma, the disappearance of some fragments of bones for various reasons, and putrefaction are the main hindrances for obtaining bones with high veracity (9, 10). In these circumstances, it may be important to obtain as much data, as possible from a single bone, essential for sex estimation. The sternum has a vigorous morphology and is mostly preserved in cadavers, which makes it an immense importance in forensic studies (8). It is reported to provide 80% sex discrimination (8). The gender estimations, vital for forensic and archaeological explorations, are performed by several approaches, including DNA analysis osteometry, and odontometric data (11). However, in many situations, DNA investigation is inaccessible due to high costs, various complications in DNA extraction, and the obligation of highly skilled staff (12). On the other hand, forensic studies of the skeletal elements provide significant data for identification processes and sex identification (13). This osteometry is simple, repeatable, has a little cost, and has high correctness rates (14). The forensic studies cover topics including facial superimposition, facial reconstruction, forensic odontology, bone pathology, and archaeology. The forensic osteologist is commonly expected to have information that may establish, the identity, gender, and age of an individual from the skeletal remnants (15). When bones or skeletal remnants are dug out, the initial steps are to identify, whether its source of origin is human or animal, identification of bone Gender can be determined accurately and quite easily when a complete skeleton is available, but in forensic practice, this is not always possible. Therefore, it is of utmost importance for forensic studies to extract as much information as possible from a single bone to predict sex, age, ethnic group and subsequently establish a personal identity (16), because a statistically insignificant difference are reported in the bones of different Age groups (17). The non-metric measurements (anomalies in the normal anatomy of the skeleton) of the bone have been used in the past, however, nowadays due to advanced technologies, the metric measurements (osteometric measurements) technique using medical images, is ideal for being repeatable, accurate and less expertise required for professionals (16). The studies on the osteometric measurements of the sternum, as well as other bones have shown that the same principle cannot be applied to the different samples, as human groups vary in terms of body size, and degree of sexual dimorphism of the skeleton (18). Although sternum was not evaluated for its dimorphic characteristics, several other studies have established its osteometric properties unique for a particular gender (19). The sternum is frequently present in decomposing and skeletonized human remains which make it an even more important bone for the identification of human remains (20). It is hypothesized that the osteometric traits of the sternum will be sexually dimorphic in the peoples of District Swat.

This study aimed to thoroughly describe and explore population-specific standards for gender prediction based on sternal measurements, using Multi-slice Computed Tomography. To date, no comprehensive study and scientific information on the sternum of our locality had been carried out, therefore, this model will hopefully be of practical use in the field of forensic medicine, where the unidentified, mutilated, decomposed human remains are found, and thus reliable standards for gender prediction must be there to essentially make the identity possible. The theme of this study was to find the specific osteometric standards for gender prediction from sternal bone measurements in patients visiting Saidu Teaching Hospital Swat for routine Radiological investigation with multi-slice computed tomography. Sex determination was considered to be the cornerstone of a forensic investigation into for gender identification. Several studies have been published on sex predicting properties of the sternum in different population groups, however, there is no such study conducted on this population of District Swat. In our country there are no population-specific osteometric standards to be applied on unknown human remains to predict gender. The main objective of the present study was to find out the specific osteometric standards for gender prediction from sternal bone measurements using multi-slice computed tomography.

METHODOLOGY

STUDY DESIGN

This cross-sectional study conducted in the Radiology Department Saidu group of Teaching Hospitals Swat. The target population was among the patients who came to Saidu Teaching Hospital Swat for routine investigations with multi-slice computed tomography for chest problems.

The population included in the study were, adults aged ranged from 20 to 60 years old, belonging to a specific race (Pathan) area (Swat). This specific age group population was selected due to the easily available general population and below 20 years of age the sternum is not fully ossified and also the process of degeneration initiates after 60 years of age. It was designed to study the sternum of the normal population; therefore, patients who had chest wall pathology, traumatic lesion distorting normal sternal anatomy, and history of Coronary artery bypass grafting (CABG) were excluded from the study.

In this study, a non-probability consecutive sampling technique was followed; A total of 260 (130 each male and female) subjects were selected. Sample size calculation was done using G Power software with an effect size of 0.05, alpha 0.05, power of study 90% (Two tail). Data was collected using the patient information sheet.

Multi-slice computed tomography scans of the chest wall were routinely performed in Radiology Department STH Swat with a slice thickness of 0.5 mm which offers high-Resolution imaging using six-detector row scanner.

Images were examined for measuring sternal area, manubrium length, sternal length, manubrium width and sternal width at two levels, the measurements included in this study were performed according to (Bass 2005) [(ML+ BL) × (MW + BWa + BWb) /3] = Total sternal surface area, ML (Manubrium length), BL(Body length), MW(Manubrium width), BWa(Body widthA), BWb(Body widthB), SA(Stenal Area) (Fig. 1, Fig. 2 & Fig. 3).

STATISTICAL ANALYSIS

The above-mentioned parameters of the sternum were calculated and expressed as the mean ± standard deviation (SD) and the means of males and females were compared with an Independent t-test and multivariate regression analysis. Data were analyzed using SPSS version 20.0 (SPSS, Inc., Chicago, IL) and differences were considered significant at $P < 0.05$.

The proposed study was conducted after approval from the Institute Review Board (IRB) of Peshawar Medical College. Permission was granted from the head of Radiology Department STH.

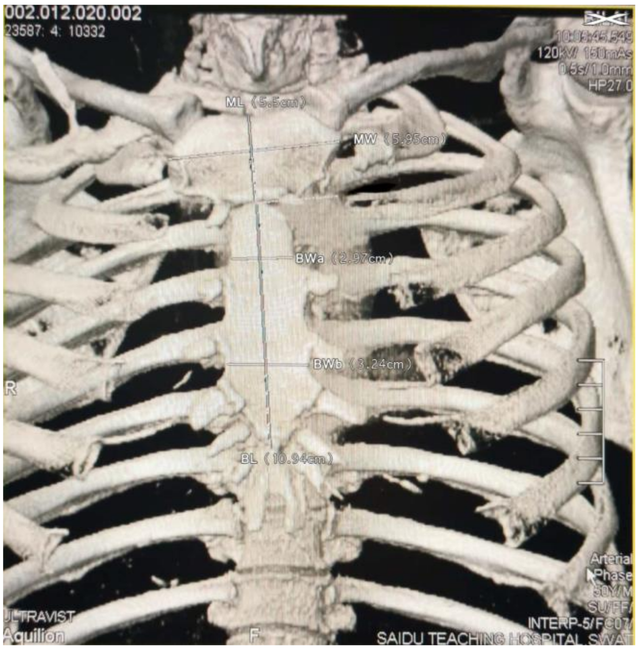

Fig. 1. Measurements of the sternal wall dimensions of male on computed tomography

RESULTS

The mean age of all samples included in this study, ranged from 20 to 60 years, was 40.39±10.13 years (Table I). In total 260 subjects (130 each male and female, mean age was 40.42±9.72 and 40.36±10.56 years, respectively). There was no statistically significant difference (p>0.05) in the age of male and female (p-value = 0.966) (Table II).

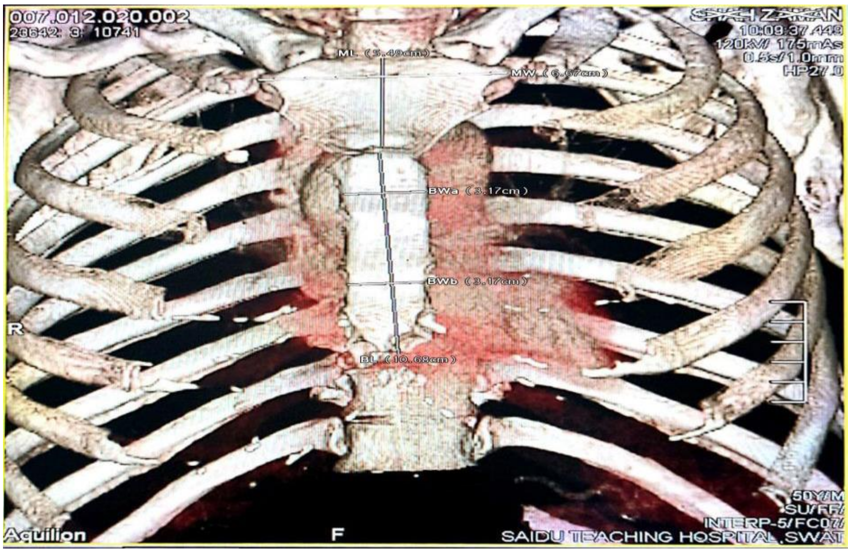

Fig. 2. Measurement of the sternal wall dimensions of male on computed tomography

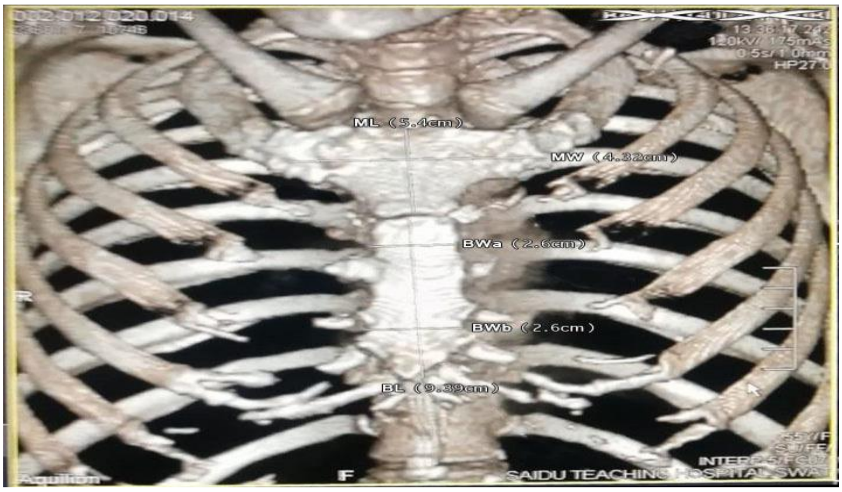

Fig. 3. Measurement of sternal wall dimensions of female on computed tomography

The mean values of ML, BL, MW, BWa, BWb, TSA in male and female subjects were (5.52±0.74 cm and 5.21± 0.78 cm),(10.89±1.27 cm and 9.41± 1.20 cm),(5.95±0.77 cm and 4.49± 0.400 cm),(3.15±0.47 cm and 2.86± 0.34 cm),(3.15±0.41 cm and 2.89± 0.34 cm) and (67.09± 0.87 cm2 and 50.03± 0.82 cm2), respectively (Table III). Mean values of ML, BL, MW, BWa, BWb, TSA were higher in male than female subjects and the difference was significant ($p<0.05$).

The accuracy of sex prediction was calculated using multivariate regression analysis from sternal measurements. The overall regression model was significant [F (4,255) = 110.52, $p<0.001$, R2 = 0.634].In this model, the most accurate predictor of gender was a combination of Manubrium length, Manubrium width and Body length (91.5%). The majority of male (43.1%, n=56) were having manubrium length greater than 5.7cm and majority of female (43.8%, n=57) were having manubrium length of 4.7 to 5.7cm (p-value = 0.002) (Table IV). The majority of male (46.0%, n=58) were having sternum body length of greater than 11 cm and majority of female (38.5%, n=50) were having sternum body length of 8.0 to 9.5 cm p-value <0.001 (Table V). The majority of male (63.8%, n=83) were having manubrium width in the range of 5.00 to 6.5 cm and the majority of female (80.8%, n=105) were having manubrium width in the range of 4.00 to 5.00cm p-value <0.001 (Table VI).

The majority of male (79.2%, n=103) were having a total surface area greater than 60cm2 and majority of female (73.1%, n=95) were having Total surface area in the range of 45.00 to 60.0 cm2 p-value <0.001 (Table VII).

DISCUSSION

In this study, we observed statistically significant differences ($p<0.05$) for manubrium length (ML) between the studied genders. Parallel to our results, earlier studies on the same sternal measurements also stated significant differences ($p<0.05$) between the genders (22,23). The average manubrium length of male

Table I. Mean and standard deviation of age (Descriptive Statistics)

	Total Number	Minimum age in years	Maximum age in years	Mean (years)	Std. Deviation
Age (years)	260	20.00	60.00	40.3962	±10.13046

Table II. Mean and standard deviation of age in male and female (Group statistics)

	Gender	N	Mean	Std. Deviation	P value
Age (years)	Male	130	40.4231	9.72240	0.966
	Female	130	40.3692	10.56038	

Table III. Sternum measurement in male and female (Group statistics)

	Gender	N	Mean	Std. Deviation	P value
Manubrium length (cm)	Male	130	5.5168	0.74666	0.002
	Female	130	5.2168	0.77776	
Manubrium width (cm)	Male	130	5.9545	0.77565	<0.001
	Female	130	4.4909	0.40010	
Body length (cm)	Male	130	10.8977	1.27851	<0.001
	Female	130	9.4192	1.50550	
Body width A (cm)	Male	130	3.1585	0.47170	<0.001
	Female	130	2.8673	0.34009	
Body width B (cm)	Male	130	3.1509	0.41847	<0.001
	Female	130	2.8980	0.34242	
Total sternal surface area (cm^2)	Male	130	67.0927	0.86786	<0.001
	Female	130	50.0348	0.82194	

Table IV. Manubrium length against gender (Manubrium length groups * Gender)

	cm	Gender		Total	P value
		Male	Female		
Manubrium groups	length<4.7	19	37	56	<0.006
		14.6%	28.5%	21.5%	
	4.7-5.7	55	57	112	
		42.3%	43.8%	43.1%	
	>5.7	56	36	92	
		43.1%	27.7%	35.4%	
Total		130	130	260	
		100.0%	100.0%	100.0%	

and female obtained in this study was 5.51±0.74 and 5.21±0.77 cm, respectively. Evaluating morphological resemblances and variances in sternal osteometric data with the earlier reports are important for assessing the consistency of measurement methods. However, different values are reported for ML measured through MDCT images in a different population and regions of the world for male (M) and female (F) i.e. M: 6.07± 1.07cm, F:6.0 ±.61 cm (23), M: 4.626 cm, F: 4.3 cm (24), M:5.39cm, F: 5.03 cm (16), within the Turkish population and M:5.25 cm, F:4.82cm, (8). The average manubrium width (MW) of male and female calculated in this studym was 5.95±0.77 cm and 4.49±0.40 cm, respectively (M:4.37cm, F:4.85cm). Hindstan

Table V. Manubrium width against gender (Manubrium width groups * Gender)

	cm	Gender		Total	P value
		Male	Female		
Manubrium groups	width<4.00	0	12	12	<0.001
		0.0%	9.2%	4.6%	
	4.00-5.00	15	105	120	
		11.5%	80.8%	46.2%	
	5.00-6.5	83	13	96	
		63.8%	10.0%	36.9%	
	>6.5	32	0	32	
		24.6%	0.0%	12.3%	
Total		130	130	260	
		100.0%	100.0%	100.0%	

Table VI. Body length against gender (Body Length Group * Gender)

	cm	Gender		Total	P value
		Male	Female		
Body Length Group	<8.00	3	20	23	<0.001
		2.3%	15.4%	8.8%	
	8.0-9.5	15	50	65	
		11.5%	38.5%	25.0%	
	9.5-11	50	43	93	
		38.5%	33.1%	35.8%	
	>11.0	62	17	79	
		47.7%	13.1%	30.4%	
Total		130	130	260	
		100.0%	100.0%	100.0%	

Table VII. Total surface area against gender (Total surface area groups * Gender)

		Gender		Total	P value
		Male	Female		
Total surface area groups (cm^2)	<45.00	0	28	28	<0.001
		0.0%	21.5%	10.8%	
	45.0-60.0	27	95	122	
		20.8%	73.1%	46.9%	
	>60	103	7	110	
		79.2%	5.4%	42.3%	
	Total	130	130	260	
		100.0%	100.0%	100.0%	

population (25), (M: 4.39cm, F: 4.70cm) in Europe population (26), (M:4.84cm, F:5.14cm) in United States population (22). Therefore, osteometric standards for a specific population cannot be applied generally. The differences in the findings of the current study, with the previous studies, maybe due to the regional variances. Similar to manubrium length, different values are reported for MW measured through MDCT images in different populations and regions of the world i. e. M: 5.97± 1.17cm, F: 5.51 ± .11 cm (23). The findings of all these studies conducted in different geographical conditions are showing some similarities and also have differences with our study. It can be inferred from this study and previous reports that the values of sternum-related dimensions are very different and heterogeneous in various populations.

The BWa (Body width A) and BWb (Body width B) were found to be significantly higher (<0.001) in males than females population. Analogous results were reported (25) for the peoples of (26) for the subjects of Northwest Indian. Parallel to our results, earlier studies on the same sternal measurements also stated significant differences ($p<0.05$) between the genders (22, 23). Contrary to this study, (16) observed in African subjects that the Bwa were not significantly higher in male than female. The Bwa measured in the present was 3.15 ± 0.47 cm and 2.86 ± 0.34 cm, in male and female in the individuals of Swat. Nearly similar values (3.25 ± 0.17 cm and 2.75 ± 0.14 cm) were reported for Body width A (23). From the results of this study and earlier studies, it can be concluded that the Bwa and Bwb are also a predictor of gender identification. However, a disagreement with this study, (26) stated that the Bwa and Bwb values cannot be applicable for differentiating genders in the Iranian subjects.

In the present study, the total sternal area was significantly higher (<0.001) in male than the female population as narrated for Croatia population (27). The total sternal area measured in this research was 67.09±8.86 cm^2 and 50.03±6.82cm^2 for male and female patients, respectively. Nearly similar values (M: 63.86±7.68 cm^2, F: 50.26±7.45 cm^2) to our study were reported for Croatia population for the total sternal area (27). The total sternal area in the present study also provides accurate criteria for sex identification. It was concluded from the current study that total sternal area alone may be used for sex estimation in forensic studies. We had noted differences in all measurements of the male and female sternum. We did not further elaborate on the structure of sternum for other differences. However, (27) found no difference in the general structure of the sternum (27).

In our study, the manubrium length was highly correlated to gender, thus can easily be used for discriminating genders. The manubrium length and width of males were also significantly longer than females. According to (28), all sternal measurements were significantly greater in the males linked to the females. In this favour, the length of the manubrium had the highest correlation in both genders. Parameters measured for the sternum were greater in males compared to females ($p < 0.001$). In another similar study, conducted by (29) reported that manubrium length had the maximum correlation coefficient in both males and females (correlation coefficient: 0.721 and 0.740, respectively). These observations incurred from this study and the previously reported data recommend that sternal lengths measurements can be used for the assessment of sex. However, among the sternum measurements, ML and MW were obtained as the most reliable sternal lengths for approximating sex with an accuracy rate of over 90 %.

In the previous studies, the pelvic and craniofacial morphometric parameters yielded 95% and 77.15%, accuracy for sex estimation, respectively (8, 30). The pelvic and craniofacial bones provided the highest accuracy for sex estimation in the past, however, the sternum, did not explore thoroughly for sex estimation, give (91.5%) the most accurate predictor of gender in the current study. The sternum was also reported to provide over 80% sex discrimination property (8). The results of the present study can declare the usefulness of sternum for estimation of gender from the human remnants. The findings of our current research are parallel with earlier reported data from several researchers (2, 16, 31).

The limitations of our study included the possibility of observers bias in the measurement of the sternum and been keeping in mind that gender may be a different measurement as this was not a double-blind study. Other limitations may include the possible osteopenia especially in our female population which may affect the development of bones including the sternum. Also due to anaemia either because of nutritional deficiency or because of menstrual bleeding in female many have affected the hematopoietic site in sternum so may affect the size.

CONCLUSION

There was a significant difference in the sternum of male and female in the Pashtun population of Swat. All the measurements were significantly ($p <0.001$) lower in females as compared to males population. The most important prediction of gender is manubrium length, manubrium width and body length. These were the most useful dimensions of the sternum to discriminate genders. In other words, due to the significant differences in the dimensions of the sternum in various ethnicities, gender differentiation is possible by examining all studied parameters.

Recommendations:

1. Further studies on large scale, including different geographic and ethnic group is recommended.
2. Future studies should also focus on racial influence over the sternal bone dimensions as it has been emphasized by some authors in previous studies over the subject.
3. Direct measurement of the sternal bone dimensions during autopsies and its relation to gender discrimination is recommended.
4. Comparison of the studied values with those obtained through X Ray and direct measurement is recommended

Conflicts of interest:

The authors declare no conflict of interest.

References:

1. Grewal DS, Khangura RK, Sircar K, Tyagi KK, Kaur G, David S. Morphometric analysis of odontometric parameters for gender determination. Journal of clinical and diagnostic research: JCDR. 2017;11(8):ZC09.
2. Macaluso PJ, Lucena J. "Estimation of sex from sternal dimensions derived from chest plate radiographs in contemporary Spaniards." International journal of legal medicine. 2014; 128(2):389-395.
3. Moore KL. Thorax: Clinically Oriented Anatomy, 7thed. Lippincott Williams and Wilkins, Philadelphia. 2013; 41–42.
4. Lauretta R, Sansone M, Sansone A, Romanelli F, Appetecchia M. Gender in Endocrine Diseases: Role of Sex Gonadal Hormones. International journal of endocrinology: Int J Endocrinol. (2018).
5. Singh J, Pathak RK. Morphometric sexual dimorphism of human sternum in a north Indian autopsy sample: sexing efficacy of different statistical techniques and a comparison with other sexing methods. Forensic science international. 2013; 228:174.e1-10.
6. Singh J, Pathak RK, Singh D. Morphometric sex determination from various sternal widths of Northwest Indian sternums collected from autopsy cadavers: a comparison of sexing methods. Egyptian Journal of Forensic Sciences. 2012; 18-28.
7. Marinho L, Almeida D, Santos A, et al. Is the length of the sternum reliable for estimating adult stature? A pilot study using fresh sterna and a test of two methods using dry sterna. Forensic science international. 2012; 220:292.e1-4.
8. Ekizoglu O, Hocaoglu E, Inci E, Bilgili MG, Solmaz D, Erdil I, Can IO, Sex Estimation From Sternal Measurements Using Multidetector Computed Tomography. Medicine. 2014; 93: 27.
9. Byers SN Introduction to Forensic Anthropology: A Textbook Boston: Allyn and Bacon. 2002.
10. Haglund WD, Sorg MH. Advances in forensic taphonomy: method, theory, and archaeological perspectives, CRC Press. 2001.
11. Grewal DS, Khangura RK, Sircar K, Tyagi KK, Kaur G, David S. Morphometric analysis of odontometric parameters for gender determination. Journal of clinical and diagnostic research.. 2017; 11(8):ZC09.
12. Iwamura ES, Soares-Vieira JA, Munoz DR. Human identification and analysis of DNA in bones. Rev Hosp Clin Fac Med Sao Paulo. 2004; 59:383-8.
13. Haglund WD, Sorg MH. Advances in forensic taphonomy: method, theory, and archaeological perspectives, CRC Press. 2001.
14. Hasegawa I, Uenishi K, Fukunaga T. Ryousuke K, Motoki O. Stature estimation formulae from radiographically determined limb bone length in a modern Japanese population. Legal Medicine (Tokyo). 2009; 11:260-6.
15. Scheuer L. Application of osteology to forensic medicine. Clinical Anatomy. 2002:15 (4):297-312.
16. Ramadan SU, Türkmen N, Dolgun NA, Gökharman D, Menezes RG, Kacar M, Koşar U. "Sex determination from measurements of the sternum and fourth rib using multislice computed tomography of the chest." Forensic science international. 2010;197(1-3):120.
17. Altayeb A.A, Osman K, Magda, M. Elsayed. M. Multi-detector computed tomography for the estimation of sex from sternal medullary cavity measurements in Sudanese individuals Forensic Science International. 2021.4: 100244.
18. Ross AH, Ubelaker DH, Kimmerle EH "Implications of dimorphism, population variation, and secular change in estimating population affinity in the Iberian Peninsula." Forensic science international. 2011; 206(1-3):214.

19. Spradley MK, Jantz RL. "Sex estimation in forensic anthropology: skull versus postcranial elements." Journal of Forensic Sciences. 2011; 56(2): 289-296.
20. McCormick WF, Stewart JH, Langford LA. "Sex determination from chest plate roentgenograms." American journal of physical anthropology: Am. J. Phys. Anthropol. 1985; 68(2): 173-195.
21. Torwalt CRMM, Hoppa RD "A test of sex determination from measurements of chest radiographs." Journal of Forensic Science. 2005; 50(4): 425-426.
22. Bongiovanni R, Spradley MK. Estimating sex of the human skeleton based on metrics of the sternum. Forensic science international. 2012; 219: 2901–2907.
23. Osunwoke EA, Gwunireama IU, Orish CN, Ordu K.S, Ebowe I. A study of sexual dimorphism of the human sternum in the southern Nigerian population. Journal of applied biosciences. 2010; 26:1636–1639.
24. Rashmi J, Sternum as an index for determination of sex. Int J Anat Res 2019, 7(4.2):7070-79.
25. Dahiphale VP, Baheete BH, Kamkhedkar SG. "Sexing the human sternum in Marathwada region. Journal of the Anatomical Society of India. 2002; 51(2): 162-167.
26. Soltani S, Aghabiklooei A, Ameri M, Memarian A, Nikanzad A. Gender Identification Based on the Parameters of the Sternum Bone in the Cadavers. International Journal of Medical Toxicology and Forensic Medicine. 2020; 0(1):26740.
27. Selthofer R, Nikolic V, Mrcela T, Radić R, Leksan I, Rudez I, Selthofer K. "Morphometric Analysis of the Sternum." Collegium antropologicum. 2006; 30: 43-47.
28. Yongue GN, Kurtulus A, Bayazit O, Adiguzel E, UnalI , Demir S, Acar K. Estimation of stature and sex from sternal lengths:an autopsy study. Anatomical science international. 2014; 90:89-96.
29. Hunnargi SA, Menezes RG, Kanchan T, Lobo SW, Uysal S, Herekar NG, Krishan K, Garg RK. "Sternal index: is it a reliable indicator of sex in the Maharashtrian population of India?" Journal of forensic and legal medicine. 2009; 16 (2): 56-58.
30. Sutherland LD, Suchey JM, "Use of the ventral arc in pubic sex determination." Journal of Forensic Science. 1991; 36 (2): 501-511.
31. Fernández ED, Sáez AS, Moro JI Anthropological determination of sex by studying the sternum. Revista de la Escuela de Medicina Legal. 2007; 6:27–42.