Original article

Sexual dimorphism in sacrum

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ABSTRACT:

Background:-The bones of the body are the last to perish after death, next to the enamel of teeth. The skull, sacrum, pelvis, femur and atlas vertebra etc. can be used for sex identification.

Objectives:-1) To show the sacrum as the one of the bone for sexual dimorphism. 2) To study the accuracy and limitations of various sacral indices and measurements in identifying the sex of an adult human sacrum. 3) To identify sex in medico-legal cases.

Methods:- The material for present study is comprised of 120 dry and clean adult human sacra of known sex but of unknown age. The sacra were collected from Department of Anatomy of various Medical Institutes in Maharashtra. The various parameters were studied. The measurements were taken by using Sliding vernier caliper. The data obtained was statistically analyzed.

Results and conclusion:-The difference between the means of male and female sacra seen on Mid ventral Straight Length, Transverse Diameter of Body of S1 vertebra, Length of ala, Sacral Index, Corporo-basal Index and Alar Index was found to be statistically significant while that on the Total width of sacrum and Ventral Straight Breadth was statistically insignificant. Thus stating that sacrum is one of the bone for sexual dimorphism. Hence, further such sexual dimorphic studies from particular geographic area over a period of time will definitely help in producing the anthropometric standards which will be useful to anatomists, anthropologists and forensic experts for sexing the unknown samples of sacrum.

Key words: Sacrum, Sacral Index, Ala of Sacrum, Alar Index.

INTRODUCTION:

The bones of the body are the last to perish after death, next to the enamel of teeth. Hence, in establishing the personal identity with respect to sex, age and stature, Anatomist and Anthropologist use the skeletal material for giving their opinion[1]. Sex determination from bones is of vital importance in anthropological studies and medico-legal cases. Nearly every region and element of the skeleton has been used to develop methods for sex estimation with varying degrees of success. The general anatomical regions used for sex determination are the pelvic girdle, skull and long bones, although other bones have also been utilized.

The skull is somewhat less reliable for use in determining sex, ranging between 80 and 90 percent accuracy. The pelvic girdle is the most accurate area to determine sex and methods using the pelvic girdle tend to make successful predictions in 90 to 95 percent of individuals. Sexual dimorphism in this area is mainly due to the changes that occur during adolescence to meet the requirements of childbirth in females[2].

Sexual dimorphic characters can be studied both morphologically and metrically. In the determination of personal individuality from adult human skeletal remains, the pelvis affords the best marked and reliable characteristics for distinguishing sex in legal experts for establishing sex in 90% - 95% subjects. The sacrum has always enjoyed the attention of medico-legal experts for establishing the sex due to its contribution to the pelvic girdle and associated sex differences which are augmented due to reproductive functions, mainly influenced by sex hormones. The female sacra are shorter and wider, providing a wider pelvic cavity [3].

India is a vast country with intermixing of races, and pure ethnic groups are often difficult to get. However, Chand et al. (1995) [4] suggested that India may be divided into four regions like north, south, west, and east for different study purpose on local population.

Therefore, the present work was conducted on sacra of Maharashtra region to observe the sexual differences of male and female sacra and compare the findings with similar observations across India.

AIMS AND OBJECTIVES:

1) To show the sacrum as the one of the bone for sexual dimorphism. 2) To study the accuracy and limitations of various sacral indices and measurements in identifying the sex of an adult human sacrum. 3)To identify sex in medico-legal cases.

METHODS:

The material for present study is comprised of 120 (M:F=70:50) dry and clean adult human sacra of known sex but of unknown age. The sacra were collected from Department of Anatomy of various Medical Institutes in Maharashtra. The following parameters were studied. The measurements were taken by using Sliding vernier caliper.

1. **Mid-ventral Straight Length :-** It is measured from the midpoint of the sacral promontory to the middle of the antero-inferior border of the 5th sacral vertebra. (Fig. 1)

2. **Total width of sacrum/ Transverse diameter of base of sacrum:-** It is the maximum transverse width of the superior surface of sacrum, comprising the two alae. (Fig. 2)

3. **Ventral Straight Breadth :-** It is the straight distance across the ventral / anterior surface of the 1st sacral vertebra between the widest margins of lateral wings. (Fig. 3)

4. **Transverse Diameter of Body of S1 vertebra:-** It is the maximum transverse diameter of the articular surface of the body of 1st sacral vertebra. (Fig.4)

5. **Length of ala: -** It is the straight distance of the ala of the sacrum from the transverse diameter of the body of 1st sacral vertebra . It is measured on both the sides by taking one point on lateral most point of superior surface of body of 1st sacral body and another point on lateral most point of ala. The mean of the length of two sides is taken as the length of ala of that vertebra for calculating the alar index. (Fig.5)

By using these measurements following indices were calculated :-

1. **Sacral Index=**Anterior straight breadth of sacrum   X 100

    Mid-ventral straight length of sacrum

2. **Corporo-basal Index =**Transverse diameter of body of S1   X 100

    Width of sacrum

3. **Alar Index =**Length of ala   X 100

    Transverse dia. of body of S1

Fig. 1 - Mid Ventral Straight Length

Fig.2 – Transverse diameter of base of Sacrum

Fig. 3 - Ventral Straight Breadth

Fig. 4 – Transverse Diameter of Body of S1 Vertebra

Fig. 5 – Length of Ala

From the above metrical data following details were obtained by using formulae. They were the range, mean, standard deviation (S.D.), 't' value and 'p' value by applying Unpaired 't' test, Identification Point, calculated range, Demarking Point and percentage of bones in which sex could be identified by demarking point for each parameter. The 'p' value <0.0001 is considered to be statistically highly significant while >0.05 is considered to be statistically not significant.

The calculated range was obtained by adding and subtracting (2 X standard deviation) to and from the mean value. The calculated range (mean ± 2SD) thus obtained will cover upto 95% confidence limit. From the obtained values, demarking points (DP) were calculated on the lines of Jit and Singh (1966) [5] and percentage of bones, thus identified were found out in relation to each parameter. Any single DP for any of the parameters, if crossed would detect the sex with 100% accuracy (Singh and Raju, 1977) [6].

Thus for mid ventral straight length of sacrum, the calculated range for male is 8.47 to 11.85cm and for female is in between 7.77 to 11.64cm. Thus the demarking point for ventral straight length of sacrum for males >11.64cm and for female is <8.47cm, it means that sacrum with mid ventral straight length measuring above 11.64cm is definitely a male and below 8.47cm is definitely a female.

Identification point (IP) is a limiting point of actual range of every measurable parameter in male and female.

RESULTS:

Sr. No	Parameters	Sex	Detailed measurements				
			Mean ± SD	Calculated range	Demarking point (DP)	% of Identified bones by DP	Statistical difference
1	Mid ventral straight length (cm)	M F	10.16 ± 0.84 9.70 ± 0.97	8.47 – 11.85 7.77 – 11.64	> 11.64 < 8.47	11.42 8	Highly significant
2	Ventral Straight Breadth(cm)	M F	9.99 ± 0.58 10.14 ± 0.98	8.84 – 11.15 8.17– 12.11	<8.17 >11.15	0 16	Not significant
3	Transverse Diameter of Base (cm)	M F	10.65 ± 0.56 10.68 ± 0.93	9.52– 11.77 8.83 -12.53	<8.83 > 11.77	0 12	Not significant
4	Transverse Diameter of Body of S1 (cm)	M F	4.43 ± 0.44 3.85 ± 0.55	3.56 – 5.31 2.75 – 4.95	> 4.95 < 3.56	18.57 30	Highly significant
5	Length of Ala	M	3.29 ± 0.29	2.71 – 3.88	< 2.61	2.85	Highly

	(cm)	F	3.58 ± 0.48	2.61 – 4.54	> 3.88	40	significant
6	Sacral Index (%)	M	95.83 ± 8.82	78.18-113.46	<78.32	4.28	Highly
		F	105.30 ± 13.34	78.32-131.99	>113.46	24	significant
7	Corporo Basal Index(%)	M	41.77 ± 3.81	34.14 – 49.4	> 48.19	10	Highly
		F	36.35 ± 5.91	24.51-48.19	< 34.14	34	significant
8	Alar Index (%)	M	75.10 ± 10.54	54.02 -96.18	<51.44	1.42	Highly
		F	95.19 ± 21.82	51.55-138.83	>96.18	38	significant

DISCUSSION:

It has long been customary among anatomists, anthropologists and forensic experts to judge the sex of skeletal material by non-metric observations. Lately, sexual divergence has been based upon actual measurements in different bones. Though sacrum is often considered to be an important bone while dealing with sex differences in skeletal material, there is paucity of metrical data available for this bone. The metrical study of sacrum has been done by various authors viz. Wilder (1920) [7], Fawcet (1938) [8], Davivongs (1963) [9].

To be certain in identification, calculated range has to be considered, which is worked out by adding and subtracting 3 X standard deviations to and from the mean of any parameter. Jit and Singh (1966) [5] have called the limiting point of such calculated range as demarking points, which identify sex with 100% accuracy (Rao, 1962) [10] from any given region (Raju et al, 1980)[11].

Following tables shows comparison of the mean value of various parameters from present study with the previous studies done by various workers:

Sr. No.	Parameters	Investigators				
		Raju et al[11] (1980)	Mishra et al[12] (2003)	Sachdeva K et al[13] (2011)	Kothapalli J et al[2] (2012)	Present study (2014)
1	Mid ventral straight length (cm)	**M-**10.49 **F-**9.27	10.75 9.06	10.41 9.18	- -	10.16 9.70
2	Ventral Straight Breadth(cm)	**M-**10.53 **F-**10.3	10.53 10.58	10.31 10.17	- -	9.993 10.14
3	Transverse Diameter of Base (cm)	**M-**10.53 **F-**10.35	- -	11.18 10.44	- -	10.65 10.68
4	Transverse Diameter of	**M-**4.73 **F-**4.21	4.91 4.28	4.89 3.90	- -	4.43 3.85

	Body of S1 (cm)					
5	Length of Ala (cm)	M- - F- -	2.8 3.17	3.35 3.00	- -	3.29 3.58
6	Sacral Index (%)	M-100.85 F-111.39	98.21 117.84	100.24 111.74	104.08 115.72	99.78 105.30
7	Corporo Basal Index(%)	M-44.94 F-40.96	46.54 40.47	43.22 43.84	- -	41.77 36.35
8	Alar Index (%)	M- - F- -	56.1 72.6	- -	71.31 80.21	75.10 95.19

From the table it is observed that in present study the mean mid ventral straight length in male is 10.16cm which is less than that found by other investigators while that in case of females is 9.70cm which is greater than that found by other investigators. The mean ventral straight breadth in present study is found to less than the other investigators both in males and females. The meantransverse diameter of base is found to be near about the findings of Raju et al[11]. The mean transverse diameter of body of S1 in present study in males is 4.43cm and in females is 3.85cm which is near about the findings made by Sachdeva K et al[13]. while, the measurements of mean length of ala in present study are found to be greater than those of others which are in males 3.29cm and in females 3.58cm.

Amongst the indices, the corporobasal index is found to be more accurate in sexing the secra than other indices depending upon the % of bones identified by DP. The mean sacral index in male is 99.78% and in female is 105.30% which are nearly matching the findings of Raju et al[11] and Sachdeva K et al[13]. The mean value of corporobasal index in present study in males is 41.77% and in females is 36.35% which is lower than the other studies. While, the mean value of alar index in present is found to be more than the other studies which is 75.10% on males and 95.19% in females. The values of sacral index and alar index are found to be greater in females than in males while the corporobasal index is found to be greater in males than females.

These differences could be attributed to different geographical, environmental and racial factors.

CONCLUSION:

The difference between the means of male and female sacra seen on Mid ventral Straight Length, Transverse Diameter of Body of S1 vertebra, Length of ala, Sacral Index, Corporo-basal Index and Alar Index was found to be statistically significant while that on the Total width of sacrum and Ventral Straight Breadth was statistically insignificant. Thus stating that sacrum is one of the bone for sexual dimorphism. Hence, further such sexual dimorphic studies from particular geographic area over a period of time will definitely help in producing the anthropometric standards which will be useful to anatomists, anthropologists and forensic experts for sexing the unknown samples of sacrum.

BIBLIOGRAPHY:

1. Math SC, Nandyal VB, Shetty VB, Pawar JD, Rajkumar KR. Study of Sexual Dimorphism in Human Sacrum - in North Karnataka. Indian Journal of Forensic Medicine and Pathology2010; 3(1):13-19.

2. Kothapalli J, Velichety S, Desai V, Zameer R. Morphometric Study of Sexual Dimorphism in Adult Sacra of South Indian Population. International Journal of Biological and Medical Research 2012; 3(3): 2076–2081.

3. Mazumdar S, Ray A, Mazumdar A, Majumdar S, Sinha A, Vasisht. Sexual Dimorphism and Regional Difference in Size of Sacrum: A Study in Eastern India. Al Ameen Journal of Medical Sciences 2012; 5(3):298-307.

4. Chand P, Mukherjee B, Sahai A. An Anthropometric Study of Sacrum in North Indians. *J* Anat. Sciences 1995; 14:6-8.

5. Jit I and Singh S. Sexing of the Adult Clavicle. Indian Journal of Medical Research 1966; 54:551-571.

6. Singh S, Raju PB. Identification of sex from the hip bone- demarking points. J AnatSoc India 1977; 26:111-117.

7. Wilder HH. A Laboratory Manual of Anthropometry. P. Blakistons sons &Co.Philadelphia1920; 119 &193.

8. Fawcet E. The sexing of the human sacrum. Journal of Anatomy London 1938; 72:638.

9. Davivongs V. The pelvic girdle of the Australian Aborigine, sex differences and sex determination. Am. J Phys. Anthrop. 1963; 21(4):443-455.

10. Rao CR. In advanced statistical method in biometric research. Johnwiley& Sons, Inc. London 1962; 291-296.

11. Raju PB, Singh S, Padmanabhan R. Sex determination and sacrum. *J* Anat. Soc. India 1980; 30(1):13-15.

12. Sachdeva K, Singla RK, Kalsey G, Sharma G. Role of sacrum in sexual dimorphism – A morphometric study. J Indian Acad Forensic Med2011; 33(3):206-210.

13. Mishra SR, Singh PJ, Agrawal AK, Gupta RN. Identification of Sex of Sacrum of Agra Region. *J* Anat.   Soc. India 2003; 52(2):132-136.