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DETERMINATION OF SEX USING DRY ADULT HUMAN SACRUM- A MORPHOMETRIC STUDY

Nisha Yadav¹, Kopal Saini¹, Kalpana Patil²

¹Department of Anatomy, S.B.H. Govt. Medical College, Dhule, Maharashtra, India; ²Department of Anatomy, GMC Aurangabad, Maharashtra, India.

ABSTRACT

Aim: To find out similarities and differences in the metrical values of different sacral parameters in males and females and to highlight the best parameter that could be used to study sexual dimorphism of sacrum.

Materials and methods: 140 (83 male and 57 female) adult human sacra were collected from Department of Anatomy, Government Medical College, Aurangabad, Maharashtra. The measurements included ventral straight length and maximum breadth of sacrum, sacral index, maximum transverse and antero-posterior diameter and index of body of first sacral vertebra. Demarking points for these parameters were used for identification of sex of sacrum.

Results: The average values of sacrum for ventral straight length was found to be 104.7±5.94 mm in male and 92.6±6.1 mm in female, maximum breadth was 102.93±4.83 mm in male and 104.77±6.48 mm in female and sacral index was 98.44±4.69 mm in male and 113.23±5.61 mm in female. The average values of first sacral vertebra for transverse diameter was 48.48±4.21 mm in male and 40.75±3.51 mm in female, antero-posterior diameter was 29.12±2.47 mm in male and 26.93±2 mm in female and index was 60.28±4.96 mm in male and 66.36±5.04 mm in female.

Conclusion: Sacral index was found to be the best parameter for sex determination of sacrum amongst the parameter studied. Using sacral index alone 27.71% of bones in males and 57.9% of bones in females could be identified. However not a single parameter could identify 100% of the bones.

Key Words: Sacrum, Sacral index, Vertebra

INTRODUCTION

Determination of sex is an integral part and first step in the development of the biological profile in human osteology. Sex determination is necessary to make age, ancestry and stature estimations.¹ Anatomists and anthropologists since long acknowledged the importance of sacrum in identifying the sex of a deceased person. Sexual dimorphic characters of sacrum can be studied both morphologically and metrically.

Sacrum is a large triangular bone forming the postero-superior wall of the pelvic cavity, wedged between the two innominate bones. It is formed by the fusion of five sacral vertebrae and forms the caudal end of the vertebral column.²

The well known method for determination of male or female type of sacrum has always been the "Sacral Index". The Sacral Index is calculated by the following formula: Sacral Index = Width of Sacrum x 100 / Height of Sacrum.²

The present study was undertaken to find out similarities and differences in the metrical values of different sacral parameters in males and females and also to highlight the best parameter that could be used to study sexual dimorphism of sacrum.

MATERIALS AND METHODS

The present study was performed on 140 (83 male and 57 female) adult human sacra of known sex. Sacra were dry and free from deformity and fully ossified. Sacra were obtained from Department of Anatomy, Government Medical College, Aurangabad, Maharashtra. Each sacrum was studied for different features of sexual dimorphism. The parameters were measured using sliding vernier callipers, pair of divider and steel measuring scale. The following parameters were considered:

1. Maximum length of sacrum (Ventral straight length) was measured from the midpoint of the

Corresponding Author:

Kopal Saini, Department of Anatomy, S.B.H. Govt. Medical College, Dhule, Maharashtra, India.

Email: dr.kopsaini@gmail.com

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- anterosuperior margin of sacral promontory, in the midsagittal plane, to the midpoint of antero-inferior margin of the last sacral vertebra. (Photograph 1)
- Maximum breadth of sacrum was noted at midpoint of left and right alae of sacrum. (Photograph 2)
 - Sacral index for each sacrum was calculated using formula: Sacral index = (sacral width / sacral ventral straight length) x 100
 - Maximum transverse diameter of first sacral body (T-S1) was recorded. (Photograph 3)
 - Maximum antero-posterior diameter of 1st sacral body (AP-S1) was noted. (Photograph 4)
 - Index for body of 1st sacral vertebra was calculated using formula: A-P Diameter of body of S1 / Transverse diameter of S1 x 100
- For identification of Male sacrum, the demarking point (D.P) of a particular measurement was more than 3 S.D. of mean value for female, and, for identification of Female sacrum, the D.P of same measurement was less than 3 S.D. of mean value for male.³ Data were tabulated and statistically analyzed for mean, standard deviation, range, student t test, demarking points and percentage of identified bones.

RESULTS

Table 1 :displaying results for ventral straight length, maximum breath and sacral index. (H.S. - highly significant, N.S. - not significant, measurements in millimeters)

Parameters	Ventral straight length		Maximum breadth		Sacral index	
	Male	Female	Male	Female	Male	Female
Number of bones	83	57	83	57	83	57
Range	90.35 -122.39	81 - 110.64	92.65-115.65	88.98 – 126.54	86.78 - 116.09	99.13 - 123.11
Mean	104.73	92.64	102.93	104.77	98.44	113.23
Standard deviation (S.D.)	5.94	6.10	4.83	6.48	4.69	5.61
Mean ± 3 S.D.	86.91 -122.55	74.34 -110.94	88.44 -117.42	85.33 -124.21	84.37 -112.51	96.4 – 130.06
Demarking points	> 110.94	< 86.91	>124.21	<88.44	< 96.4	>112.51
Percentage of bones identified	16.86	19.30	0	0	27.71	57.9
t value	11.71		1.923		16.93	
p value	< 0.0001 (H.S.)		< 0.0566 (N.S.)		< 0.0001 (H.S.)	

Table 2: displaying results for maximum transverse diameter (T-S1), maximum antero-posterior diameter (AP-S1) and index of body of first sacral vertebra. (H.S. - highly significant, N.S. - not significant, measurements in millimeters)

Parameters	T-S1		AP-S1		Index of body- 1 st sacral vertebra	
	Male	Female	Male	Female	Male	Female
Number of bones	83	57	83	57	83	57
Range	40 – 62.1	34 – 48.02	22.26 –37.42	23.09 –30.73	48.47 –72.02	56.08 –77.52
Mean	48.48	40.75	29.12	26.93	60.28	66.36
Standard deviation (S.D.)	4.21	3.51	2.47	2.00	4.96	5.04
Mean ± 3 S.D.	35.85 –61.11	30.22 –51.28	21.71 –36.53	20.93 –32.93	45.4 – 75.16	51.24 –81.48
Demarking points	> 51.28	< 35.85	>32.93	< 21.71	<51.24	> 45.4
Percentage of bones identified	18.07	10.53	2.40	0	1.43	0.71
t value	11.39		5.577		7.085	
p value	< 0.0001 (H.S.)		< 0.0001 (H.S.)		< 0.0001(H.S.)	

DISCUSSION

Jit and Singh³ (1966) identified sex of sacrum with 100% accuracy by calculating demarking points from the observed values. They suggested for identification of Male sacrum, the D.P. of a particular measurement was more than 3 S.D. of mean value for female, and, for identification of Female sacrum, the D.P. of same measurement was less than 3 S.D. of mean value for male.

In the present study, most of the values for parameters like sacral index, index of first sacral vertebra, width of sacrum were higher in female and other parameters like length of sacrum and diameters of first sacral vertebra were higher in male. The mean value of sacral index was 98.44 in males and 113.23 in females. The demarking points in males was <96.4 and > 112.51 in females. Of the specimens studied, 27.71% of bones in males and 57.9% of bones in females were identified correctly using this parameter alone with high level of significance (P < 0.0001).

Gray's Anatomy² (40th edition) gives the mean value of sacral index to be 105 in males and 115 in females.

Mishra SR⁴ et al (2003) obtained mean value of sacral index to be 98.21 in males and 117.84 in females in their study conducted on 74 male and 42 female sacra. Patel MM⁵ et al (2005) in their study on 32 male and 32 female sacra found the mean value to be 96.25 in males and 113.25 in females. Shailaja MC⁶ et al (2010) in their study on 190 male and 64 female sacra showed the mean value to be 94.24 in males and 113.19 in females.

On the contrary, the studies conducted by Jana⁷ et al (1987), Singh⁸ et al (1988) and Mazumdar⁹ S et al (2012) showed the mean value of sacral index to be on lower side in both sexes as compared to present study.

Nevertheless sacral index still remains to be the best parameter for sex determination amongst the parameters studied. Other parameters studies showed low level of significance compared to sacral index. Perhaps sacral index can be used in combination with other parameters to improve the accuracy of sex determination.

Table 3: showing comparison of present study with other studies for ventral straight length, maximum breadth and sacral index.

Parameter	Mean \pm standard deviation							
	Sample size		Ventral straight length		Maximum breadth		Sacral index	
	M	F	M	F	M	F	M	F
Grays anatomy	-	-	-	-	-	-	105	115
Davivongs (1963)	50	50	9.65 \pm 0.88	8.81 \pm 0.687	9.99 \pm 0.5	10.12 \pm 0.51	104.16 \pm 8.93	115.49 \pm 10.39
Flander (1978)								
White	50	50	-	-	-	-	106.49 \pm 10.4	108.69 \pm 13.59
Black	50	50	-	-	-	-	106.17 \pm 10.36	112.35 \pm 11.03
Raju et al (1980)	33	11	10.5 \pm 0.864	9.27 \pm 0.561	10.5 \pm 0.531	10.3 \pm 0.36	100.85 \pm 8.71	111.39 \pm 7.67
Jana et al (1987)	27	27	-	-	-	-	91.27	103.89
Singh et al (1988)	26	12	-	-	-	-	94.32	104.81
Mishra SR et al (2003)	74	42	107.53 \pm 7.03	90.58 \pm 4.42	105.34 \pm 6.22	105.16 \pm 6.32	98.21 \pm 4.89	117.84 \pm 7
Patel MM et al(2005)	32	32	-	-	-	-	96.25 \pm 4.6	113.25 \pm 5.74
Shailaja MC (2010)	190	64	11 \pm 0.84	9.45 \pm 0.85	10.42 \pm 0.9	10.6 \pm 0.69	94.24 \pm 11.78	113.19 \pm 10.26
Arora AK etal (2010)	20	20	109.74 \pm 11.66	91.22 \pm 6.348	101.44 \pm 8.96	114.13 \pm 9.67	93.69 \pm 11.57	125.35 \pm 11.47
Sachdeva K et al (2011)	40	10	10.41 \pm 1.26	9.18 \pm 0.71	10.31 \pm 0.78	10.1 \pm 0.7	100.24 \pm 12.54	111.14 \pm 14.6
Mazumdar S et al (2012)	127	123	100.8 \pm 11.5	87.3 \pm 7.4	96.3 \pm 7.4	95.6 \pm 5.7	94.9 \pm 4.8	109.8 \pm 7.3
Present Study	83	57	104.7 \pm 5.94	92.6 \pm 6.1	102.93 \pm 4.83	104.77 \pm 6.48	98.44 \pm 4.69	113.23 \pm 5.61

Table 4: showing comparison of present study with other studies for parameters like transverse diameter (T-S1), antero-posterior diameter (AP-S1) and index of body of first sacral vertebra

Parameter	Mean \pm standard deviation							
	Sample size		T-S1		AP-S1		Index of body- 1 st sacral vertebra	
Studies	M	F	M	F	M	F	M	F
Davivongs (1963)	50	50	4.74 \pm 0.399	4.41 \pm 0.368	2.98 \pm 0.229	2.76 \pm 0.148	63.03 \pm 4.4	62.84 \pm 6.25
Raju et al (1980)	33	11	4.73 \pm 0.509	4.21 \pm 0.509	3.3 \pm 0.288	2.76 \pm 0.28	64.42 \pm 7.48	65.52 \pm 6.27
Mishra SR et al (2003)	74	42	49.12 \pm 3.27	42.81 \pm 3.04	30.04 \pm 2.58	29.29 \pm 2.15	61.73 \pm 4.07	68.60 \pm 4.92
Sachdeva K et al (2011)	40	10	4.76 \pm 0.71	4.55 \pm 0.48	3.15 \pm 0.41	2.85 \pm 0.23	-	-
Kothapalli J et al (2012)	-	-	-	-	-	-	66.79 \pm 7.31	66.75 \pm 8.83
Mazumdar S et al(2012)	127	123	41.6 \pm 8.5	39.7 \pm 5.2	29.4 \pm 3.8	27.9 \pm 2.7	71.6 \pm 9.1	70.7 \pm 5.8
Shree Krishna et al(2013)	75	75	-	-	-	-	64.33 \pm 6.43	69.40 \pm 6.9
Present study	83	57	48.48 \pm 4.21	40.75 \pm 3.51	29.12 \pm 2.47	26.93 \pm 2	60.28 \pm 4.96	66.36 \pm 5.04

CONCLUSION

The present study shows that the sacral index is the best criterion for sex determination of sacrum. Using sacral index alone 27.71% of bones in males and 57.9% of bones in females could be identified. Other parameters studied like ventral straight length, maximum breadth, diameters and index of first sacral body were less significant for sex determination of sacrum. However not a single parameter could identify 100% of the bones. Hence it could be concluded that for determination of sex of sacrum, maximum number of parameters should be taken into consideration to attain 100% accuracy.

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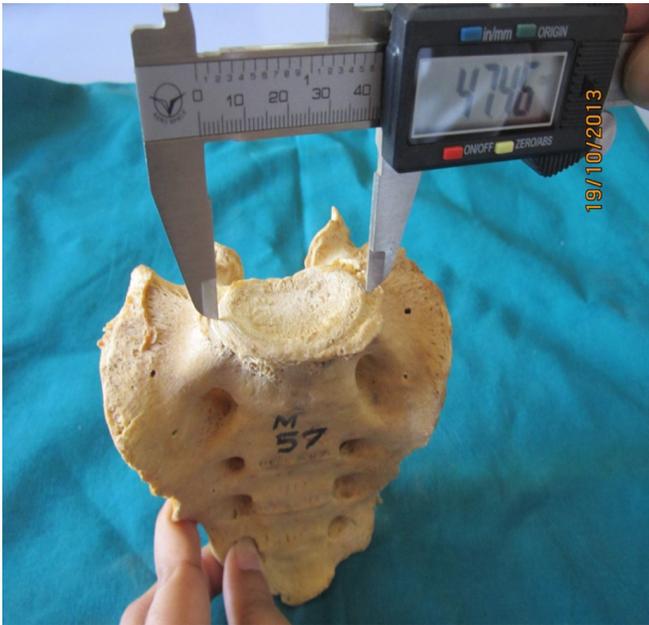
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Photograph 1: Showing measurement of ventral straight length of sacrum



Photograph 2: Showing measurement of maximum breadth of sacrum



Photograph 3: Showing measurement of maximum transverse diameter of first sacral body



Photograph 4: showing measurement of antero-posterior diameter of first sacral vertebra.