

Study of Various Sacral Indices in Sexual Dimorphism in the Region of Gujarat

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Abstract

Context: Sacrum shows sexual dimorphism and hence functionally influences the pelvis. Sexual dimorphism is also influenced by the interaction between the environmental and genetic factors. Based on various sacral indices gender discrimination of the skeletal material can be done to establish the identity of the individual. *Aims:* To study various sacral indices in sexual dimorphism in the region of Gujarat and compare it with other studies. *Settings and Design:* Various sacral dimensions of dry sacra were measured with the help of vernier calliper and flexible tape. Various sacral indices were calculated and statistically analysed. *Methods and Material:* The study was conducted on 110 adult sacra dry bone of known sex (62male and 48 female) obtained from the department Anatomy, GMC Surat, SMIMER and BJMC Ahmadabad. *Statistical analysis used:* The observations were tabulated for quantitative variable (Mean \pm 3SD). Two independent sample t test was applied to check group mean differences. The minimum in male range (A to B) and maximum in female range (C to D) were chosen as demarking points respectively for females and males. *Results:* In the present study the P value of various sacral indices was found to be less than 0.005 and thus highly significant. *Conclusions:* Based on various sacral indices and demarking points the sexual dimorphism of sacrum can be established with increased accuracy. The metric parameters are significantly different for different population groups.

Keywords: Sacral Indices; Demarking Points; Male; Female; Sexual Dimorphism.

Introduction

The Sacrum is a large, triangular bone formed by the fusion of the five sacral vertebra. In an articulated pelvis, it forms the posterior boundary of the pelvic cavity. It is wedge shaped and it is placed obliquely in between two hip bones.

It articulates above with the fifth lumbar vertebra at the lumbosacral angle and at the caudal end it articulates with the coccyx. It forms the caudal portion of axial skeleton and also contributes to the formation of pelvic girdle. Its morphology and morphometry influences the functional differences in the pelvic

region between the two sexes. It has been customary among anatomists, anthropologists, and forensic experts to identify sex of skeletal material by metric and non metric observations. Sacrum is an important bone for this purpose, both as an Individual bone and as a part of pelvis.

The purpose of the present study is to measure various sacral indices and its significance in sexual dimorphism in the population of Gujarat and compare it with other studies.

Subjects and Methods

The study was conducted on 110 adult sacra dry bone of known sex (62male and 48female) obtained from the department Anatomy, GMC Surat, SMIMER and BJMC Ahmadabad. Following measurements as shown in (Figure 1,2,3,4,5) were taken with the help of digital vernier calliper, & flexible tape.

By using these measurements various sacral indices were calculated as follows-

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1. Sacral index

$$= \frac{\text{Width of the sacrum}}{\text{Straight length of sacrum}} \times 100$$
2. Curved index

$$= \frac{\text{Straight length of sacrum}}{\text{Mid ventral curved length of sacrum}} \times 100$$
3. Index of the body of 1st sacral vertebra

$$= \frac{\text{A-P diameter of the body of the 1st sacral vertebra}}{\text{Transverse diameter of the body of 1st sacral vertebra}} \times 100$$
4. Corporo-basal index

$$= \frac{\text{Transverse diameter of body of 1st sacral vertebra}}{\text{Width of sacrum}} \times 100$$
5. Auricular index

$$= \frac{\text{Length of auricular surface}}{\text{Width of the sacrum}} \times 100$$



Fig. 1: Curved length of ventral surface of sacrum

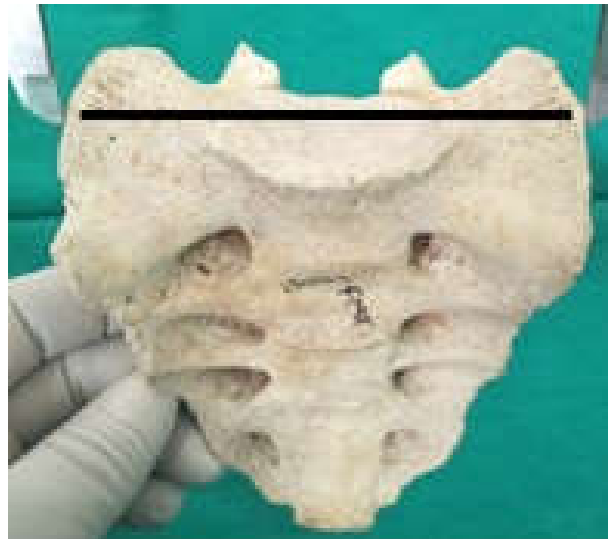


Fig. 3: Width of base of sacrum



Fig. 2: Straight length of sacrum



Fig. 4: Transverse and AP diameter of body of S1 vertebra



Fig. 5: Length of auricular surface of sacrum

The observations were tabulated for quantitative variable (Mean \pm 3SD). Two independent sample t test was applied to check group mean differences. The minimum in male range (A to B) and maximum in female range (C to D) were chosen as demarking points respectively for females and males. Sacrum with measurement less than A were considered as female sacra and greater than D were considered as male sacra according to curvature index and corporobasal index. Sacra with measurement less than C were identified as male sacra and greater than D were identified as female sacra according to sacral index, Index of body of S1 and auricular index. In all indices measurements p-value of < 0.05 was considered as statistically significant parameter for sex determination of sacra.

Results

As depicted from table 1 the p value of all the sacral indices i.e sacral index, curvature index, corporobasal index, Index of body of first sacral vertebra and auricular index is < 0.05 that means statistically highly significant. The percentage of bone identified by demarking points (DP) is maximum with sacral index i.e 17.74% in males and 42.86% in females. Identification by demarking points of auricular index appears to be maximum in male sacra i.e 24.19%. Sex determination by considering demarking points of all other indices is less effective. Gender discrimination in very few sacra is possible by using demarking points for each sacral index as depicted in table 1 due to overlapping values. If demarking points is

calculated by considering all the sacral indices then gender detection of almost 92% of the sacra can be done.

Discussion

Sacrum is a very important bone to determine the sex of skeleton. Interaction between the environmental and genetic factors influence the development of bones. While teaching sex difference in bones much stress is laid on the importance of sacrum. There is paucity of available data to test the validity of the number of parameters described to identify the sex of sacrum [15]. As seen from Table 1 the P value of all sacral indices i.e Sacral index, Curvature Index, Corporobasal index, auricular index and index of body of first sacral vertebra is less than 0.05 suggesting that all these sacral indices are highly significant. These findings concur with those of U U joshi et al. [2], Raju P.B et al. [3], Davivongs [1] and Renuka [4]. If only sacral index is used 53.33% of male sacra and 46.67% of female sacra can be accurately identified [5]. If all indices are considered accuracy of sex determination is further increased.

In the present study and studies done by other authors (Table 2a,2b,2c,2d) all the dimensions i.e mean length, mean width, mean curve length, mean transverse diameter of body of S1, mean auricular length, are more in males as compared to females except the mean AP diameter of S1 vertebra. The mean AP diameter of S1 vertebra is significantly higher in females as compared to males in the present study. The mean AP diameter of Female S1 vertebra is also significantly higher when compared with other studies.

As seen from Table 2b all the sacral indices are higher in males as compare to females except the index of body of S1 vertebra which is the other way round in all population groups. However, Snell [6] has reported the index of body of S1 vertebra to be lower in females than males. According to Snell [6] and Frazer [7] the female sacrum is broad and curves sharply at the lower end, while in males it is more or less uniformly curved. This is due to the functional differences of the male and female pelvis.

In the present study (Table 2c) the mean sacral index in males is 97.66mm which categorises it into dolichoheric type. These findings are similar to the studies done by Mishra et al. [8] and Patel et al. [9].

Table 1: Observations

Sr. No.	Parameters	Sex	Range	Mean	SD	T Value	P value	Calculated Range: Mean+/-3SD	DP	% of Bone Identified By DP
1	Length of sacrum	M	90-125	104.55	7.53	6.63	<0.0001	81.96-127.14	>118.53	
		F	80-113	94.66	7.89			70.79-118.53	<81.96	
2	Width of sacrum	M	85-117	101.53	5.80	3.56	<0.001	84.13-118.93	<86.98	0
		F	94-117	105.67	6.23			86.98-124.36	>118.98	0
3	Curve length of sacrum	M	96-138	112.03	8.49	4.76	<0.0001	86.56-137.50	>131.07	3.22
		F	88-125	103.98	9.03			76.89-131.07	<86.56	0
4	Transverse Diameter of body of 1 st sacral vertebra	M	40-58	46.53	4.27	1.81	>0.05	33.72-59.34	>56.11	0
		F	35-52	30.85	2.70			35.35-56.11	<33.72	0
5	Antero-posterior diameter of 1 st sacral vertebra	M	24-36	29.89	2.80	1.10	>0.05	21.49-38.29	<22.75	0
		F	25-36	45.73	3.46			22.75-38.95	>38.95	0
6	Length of auricular surface	M	50-66	56.08	4.13	1.63	>0.05	43.69-68.47	>67.25	0
		F	46-60	54.77	4.16			42.29-67.25	<43.69	0
7	Sacral index	M	89.90-108	97.66	5.29	12.68	<0.0001	81.79-113.53	<92.08	17.74
		F	101.85-130.95	112.12	6.68			92.08-132.16	>113.53	42.86
8	Curvature index	M	89.23-98.14	93.28	2.37	3.04	<0.01	86.17-100.39	<78.55	0
		F	83.16-97.97	91.21	4.22			78.55-103.87	>100.39	0
9	Corporobasal index	M	40-53.06	45.85	3.39	3.82	<0.001	35.66-56	>52.82	1.61
		F	34.86-50	43.46	3.12			34.10-52.82	<35.66	2.08
10	Index of the body of 1 st sacral vertebra	M	56-72.91	64.38	4.35	3.54	<0.001	44.89-65.59	<38.67	0
		F	56-76.91	67.68	5.20			38.67-65.67	>65.59	0
11	Auricular index	M	47.23-61.32	55.24	3.45	3.94	<0.001	55.33-77.43	<52.08	24.19
		F	42.10-60.60	52.17	4.50			52.08-83.28	>77.43	0

Table 2a: Comparison of mean of length, width and curve length of present study with other studies

Sr. No.		Mean length (mm)	Mean width (mm)	Mean Curve length (mm)
1	Present Study in Gujrat	Male -104.55	Male - 101.53	Male - 112.03
		Female - 94.66	Female - 105.67	Female - 103.98
2	A K Arora et al (2010) ²⁰ study in Punjab	Male - 109.74	Male - 101.94	
		Female - 91.22	Female - 114.22	
3	Anil Kumar et al ¹⁹ (2013)	Male - 102.7	Male - 99.9	Male - 116.4
		Female - 93.5	Female -109.5	Female - 110.7
4	Shailendra Patel et al ¹⁸ (2014) Study in Madhya Pradesh	Male - 109.47		
		Female - 94.46		
5	Arpan Dubey et al ⁵ (2016)	Male - 113.5	Male - 105.83	
		Female -94.6	Female - 104.33	
6	Shweta Asthana et al ¹⁷ (2014)	Male - 106.96	Male - 103.07	
		Female - 90.52	Female - 102.67	
7	Maddikunta V et al ¹⁶ (2014) Study in Telangana	Male - 113.9	Male - 104.2	Male - 125
		Female - 90	Female - 103.4	Female - 100
8	Kataria et al ¹⁴ (2014) study in Rajasthan	Male - 106.7	Male - 110.3	
		Female - 91.91	Female - 109.88	
9	William F Manish ¹⁵ (2017) (Rajasthan)	Male - 107.44	Male - 104.63	
		Female - 91.65	Female - 102.77	
10	Mishra et al ⁸ (2003)	Male - 107	Male - 105.34	Male - 119.56
		Female - 90.58	Female - 105.79	Female - 100.95
11	Raju and Singh ³ et al (1981)	Male - 104.96	Male - 103	Male - 112.75
		Female -92.72	Female -105.33	Female -104.81
12	Flander et al ¹¹ (1978)	White Americans	White Americans	White Americans
		Male - 110.20	Male - 116.42	Male - 128.36
		Female - 109.64	Female - 117.62	Female - 124.72
		Black Americans	Black Americans	Black Americans
13	Stradalova et al ¹² (1974)	Male - 105.50	Male - 111.14	Male - 120.6
		Female - 99.98	Female - 111.36	Female - 111.72
14	Davivongs et al ¹ (1963) (Study on African Aborigines)	Male - 101	Male - 117.25	Male - 115.86
		Female -98.47	Female -114.94	Female -112.15
14	Davivongs et al ¹ (1963) (Study on African Aborigines)	Male - 96.52	Male - 99.92	Male - 104.34
		Female - 88.12	Female - 101.24	Female - 97.08

Table 2b: Comparison of mean of various dimensions of present study with other studies

Sr. No.		Mean transverse diameter of body of S1 (mm)	Mean AP diameter of body of S1 (mm)	Mean length of Auricular surface (mm)
1	Present Study in Gujrat	Male - 46.53 Female - 30.85	Male - 29.89mm Female - 47.73mm	Male - 56.08mm Female - 54.73mm
2	Anil Kumar et al ¹⁹ (2013)	Male - 53 Female - 51.4	Male - 30.6 Female - 30.5	
3	Maddikunta V et al ¹⁶ (2014) Study in Telangana	Male - 48.7 Female - 44.9		
4	Mishra et al ⁸ (2003)	Male - 49.12 Female - 42.81	Male - 30.03 Female - 29.29	Male - 62.54mm Female - 57.02
5	Raju and Singh ³ et al (1981)	Male - 47.33 Female - 42.18	Male - 30.30 Female - 27.63	
6	Flander et al ¹¹ (1978)	White Americans Male - 52.78 Female - 46.56 Black Americans Male - 54.50 Female - 47.44	White Americans Male - 35.50 Female - 29.68 Black Americans Male - 33.58 Female - 28.80	
7	Stradalova et al ¹² (1974)	Male - 51.39 Female - 47.28		Male - 62.45 Female -57.02
8	Davivongs et al ¹ (1963) (Study on African Aborigines)	Male - 47.40 Female - 44.10	Male - 29.78 Female - 27.58	

Table 2c: Comparison of mean of sacral index of present study with other studies

Sr. No.		Mean Sacral Index	Sr. No.		Mean Sacral Index
1	Present Study	Male - 97.66 Female - 112.12	9	William F Manish ¹⁵ (2017)	Male - 97.88 Female - 112.69
2	UU Joshi et al ² (2016)	Male - 102.31 Female - 117.58	10	Patel MM et al ⁹ (2005) Study in Gujarat	Male - 96.25 Female - 113.25
3	A K Arora et al ²⁰ (2010)	Male - 93.7 Female - 125.4	11	Kataria et al ¹⁴ (2014) Study in Rajasthan	Male - 104.11 Female - 120.01
4	Anil Kumar et al ¹⁹ (2013)	Male - 97.51 Female - 117.35	12	Mishra et al ⁸ (2003)	Male - 98.21 Female - 117.84
5	Shailendra Patel et al ¹⁸ (2014)	Male - 97.61 Female - 113.4	13	Raju and Singh et al ³ (1981)	Male - 100.85 Female - 111.39
6	Arpan Dubey et al ⁵ (2016)	Male - 93.8 Female - 110.63	14	Flander et al ¹¹ (1978)	White Americans Male - 106.49 Female - 108.49 Black Americans Male - 106.17 Female - 112.35
7	Shweta Asthana et al ¹⁷ (2014)	Male - 96.25 Female - 113.33	15	Davivongs et al (1963) ¹ (Study on African Aborigines)	Male - 104.16 Female - 115.49
8	Maddikunta V et al ¹⁶ (2014) Study in Telangana	Male - 91.8 Female - 116.3	16	Grays Anatomy ¹³ (2008)	Male - 105 Female - 115

Table 2d: Comparison of mean of curvature and corporobasal index of present study with other studies

Sr. No.		Mean Sacral Index	Sr. No.		Mean Sacral Index
1	Present Study	Male - 97.66 Female - 112.12	9	William F Manish ¹⁵ (2017)	Male - 97.88 Female - 112.69
2	UU Joshi et al ² (2016)	Male - 102.31 Female - 117.58	10	Patel MM et al ⁹ (2005) Study in Gujarat	Male - 96.25 Female - 113.25
3	A K Arora et al ²⁰ (2010)	Male - 93.7 Female - 125.4	11	Kataria et al ¹⁴ (2014) Study in Rajasthan	Male - 104.11 Female - 120.01
4	Anil Kumar et al ¹⁹ (2013)	Male - 97.51 Female - 117.35	12	Mishra et al ⁸ (2003)	Male - 98.21 Female - 117.84
5	Shailendra Patel et al ¹⁸ (2014)	Male - 97.61 Female - 113.4	13	Raju and Singh et al ³ (1981)	Male - 100.85 Female - 111.39

6	Arpan Dubey et al ⁵ (2016)	Male - 93.8 Female - 110.63	14	Flander et al ¹¹ (1978)	White Americans Male - 106.49 Female - 108.49 Black Americans Male - 106.17 Female - 112.35
7	Shweta Asthana et al ¹⁷ (2014)	Male - 96.25 Female - 113.33	15	Davivongs et al (1963) ¹ (Study on African Aborigines)	Male - 104.16 Female - 115.49
8	Maddikunta V et al ¹⁶ (2014) Study in Telangana	Male - 91.8 Female - 116.3	16	Grays Anatomy ¹³ (2008)	Male - 105 Female - 115

The mean values of all the indices differ for different states in India as seen from Table 2b. The present study when compared with other studies indicates significant sexual, racial and regional differences in the metric parameters of the sacrum. If the gender detection is done based on the demarking points calculated for each parameter the chances of error in the inference is very less. The demarking points of various parameters if crossed by any sacrum will identify the sex with certainty which is important medico legally [2,21,22,23]. However, it is not necessary for any bone to cross the demarking points of all the parameters, if crossed would detect the gender with more accuracy [3,17]. Singh and Singh [10] have inferred that demarking point should be calculated separately for different regions of population because the mean of a parameter differs in values in different regions.

Conclusion

Based on the findings of the present study the female sacrum is wider but shorter than the male for functional reasons and in consequence of this sacral index is greater in the females. In the present study the sex difference of the sacrum according to sacral index is most significant ($P < 0.00001$), but all indices, the straight length and curved length of the sacrum are significant parameters for the sex determination of the sacrum. However, not a single parameter could signify 100% gender discrimination. Hence it can be concluded that for the determination of the sex of the sacrum, maximum numbers of parameters should be taken into consideration to attain near to 100% accuracy.

Key Message

For the determination of the sex of the sacrum, maximum numbers of parameters should be taken into consideration to attain near to 100% accuracy.

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