

STUDY OF VARIOUS INDICES OF THE HUMAN SACRUM FOR SEX DETERMINATION

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DOI: 10.63001/tbs.2025.v20.i04.pp1273-1283

Key words

Length of sacrum, width of sacrum, auricular index.

Received on:

18-10-2025

Accepted on:

16-11-2025

Published on:

16-12-2025

ABSTRACT

INTRODUCTION:

The human pelvis shows marked sexual dimorphism & is used for the identification and sexing of an individual. Among the pelvic bones, sacrum forms an integral part to study the sexual dimorphic characters[Elkhateeb et al (1)]. The sacral length, sacral breadth, dimensions of first sacral vertebra, play a crucial role in sex determination particularly in dealing with incomplete skeletal remains[Ravichandra et al (2)].

MATERIAL AND METHODS:

The study was conducted on 73 dry human sacra, of unspecified sex. The gender was determined by using the length of the sacrum, width of the sacrum, transverse diameter of the body of 1st sacral vertebra, anteroposterior diameter of the body of the 1st sacral vertebra, and vertical diameter of the auricular surface by using vernier caliper. Sacral index, auricular index, corporobasal index, index of the body of S1 vertebra was also calculated.

RESULTS:

The mean sacral index is significantly higher in females (113.90 mm) than in males (97.33 mm) The mean corporobasal index is higher in male (46.63 mm) than in females (43.48 mm) .

The mean index of the body of S1 vertebra is higher in male (66.09 mm) than in females (63.04 mm). The mean auricular index was higher in male (55.44 mm) than in females (52.61 mm).

CONCLUSION:

Sacral index was significantly more in females than males and is reliable tool for sexing of the sacra.

INTRODUCTION

For the identification and sexing of an individual, human bony elements have contributed a lot in the past and it is an important component for many anthropological and medicolegal investigations. The human pelvis shows marked sexual dimorphism and these differences in morphological and morphometrical variation may be attributed to hormonal differences in both the sexes [Patel et al (3)]. Furthermore, in females, the pelvic bones are structurally adapted to facilitate birth. The sacrum supports the erect spine, provides the stability and strength to the bony pelvis to transmit the body weight and also allows considerable mobility in child bearing. Since the functions of the pelvic bone in both the sexes differ, pelvic bones are most significant for the identification of sex. Sacrum has always fascinated anthropologists, paleodemographers, anatomists, and forensic experts as it is often contemplated as a crucial bone and thought to reflect the sexual dimorphism as it contributes to the formation of pelvic girdle. Different populations have different morphometric parameters of sacrum and this leads to variations in sacral index [Singh H et al (4)]. The best parameter in identifying the sex of the sacrum is sacral index. The sacral index plays a crucial role as sex determining parameter as observed in previous literature among various populations [Davivong et al (5)]. Sexual dimorphism of skeletal structure develops during childhood and becomes evident at adolescence. Based on the anatomical features and the role within the pelvic structure, the sacrum contributes to the accuracy of sex determination in human skeletal material [Kumar et al (6)]. Since there is a lack of cognizance of various indices of the sacrum, the present study was undertaken to measure them and to know its significance in determination of sex.

AIM: To know the significance of various indices of the sacrum with respect to gender estimation.

OBJECTIVE: To measure the morphometric parameters of sacrum and to calculate the indices of the sacrum in order to determine the gender of the sacrum.

MATERIAL AND METHODS

After obtaining approval from Institutional ethics committee, the study was conducted in the department of Anatomy, Mahatma Gandhi Medical College & Research Institute, Puducherry on 73 dry human sacra of unknown sex. Classification of the sex of sacrum was determined by measuring various morphometric parameters of sacrum and by calculating the indices of the sacrum, the bones were categorized as 40 male sacra and 33 female sacra.

Inclusion criteria- Fully ossified sacral bones without any damage or variation were taken for the study.

Exclusion criteria- Sacral bones with pathological deformity, developmental anomalies, mutilation, fractures or post-mortem damage that could alter morphometric measurements were excluded.

Equipments used for the study-

- 1) Digital vernier calliper
- 2) Divider
- 3) Flexible ribbon tape
- 4) Steel measuring scale.

Statistical analysis – The collected data was entered into a table using Microsoft Excel. Results were described as mean \pm standard deviation (SD), using Student's t- test, morphometric dimensions of male and female sacra were compared and p values were determined. The level of significance was set as p value ≤ 0.05 . While p ≥ 0.05 is considered to be statistically not significant.

Human sacral bones play an important role in identification of gender. In order to identify the sexual dimorphism, the following morphometric parameters were measured.

- 1) Length of the sacrum – Maximum straight length was noted in millimetres with the help of vernier callipers along the ventral midline of the sacrum from the middle of anterosuperior margin of the sacral promontory to the middle of antero-inferior margin of the fifth sacral vertebra.

- 2) Width of the sacrum – Maximum sacral breadth was measured in millimetres between the lateral most part of left and right ala of the sacrum.
- 3) Transverse diameter of the body of 1st sacral vertebra- The maximum width of the body of the first sacral vertebra was measured in millimetres by taking the lateral most point on each side of the superior surface of the S1 vertebral body.
- 4) Anteroposterior diameter of the body of the 1st sacral vertebra – The maximum anteroposterior distance was measured in millimetres by using vernier callipers by taking one point on the antero-superior border and another point on the postero-superior border of the first sacral vertebra.
- 5) Vertical diameter of the Auricular surface – measured in millimetres using vernier calliper from midpoint of upper to lower part of auricular surface.
- 6) Sacral index: Sacral index is calculated by using the formula:

Sacral index = $\frac{\text{Maximum breadth across the base} \times 100}{\text{Length from promontory to apex}}$

- 7) Auricular index: Auricular index is calculated by using the formula:

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

- 8) Corporobasal index: Corporobasal index is calculated using the formula:

$\frac{\text{Transverse diameter of body of 1st sacral vertebra} \times 100}{\text{Width of the sacrum}}$

- 9) Index of the body of 1st sacral vertebra: Index of the body of 1st sacral vertebra is calculated using the formula

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

RESULTS

The mean maximum sacral length is significantly higher in males (101.45 mm) compared to females (89.69mm)

The mean maximum sacral breadth is higher in females (102.21 mm) compared to males (98.83mm)

Antero-posterior diameter of S1 vertebra is higher in males (29.49 mm) compared to females (29.08 mm)

Transverse diameter of S1 vertebra higher in males (46.16 mm) compared to females (44.50mm).

The mean maximum length of auricular surface is higher in males (54.82mm) compared to females (53.82 mm).

The mean sacral index is significantly higher in females (113.90 mm) than in males (97.33 mm).

The mean corporobasal index is higher in male (46.63 mm) than in females (43.48 mm).

The mean index of the body of S1 vertebra is higher in male (66.09 mm) than in females (63.04 mm) .

The mean auricular index is higher in male (55.44 mm) than in females (52.61 mm).

Table 1: shows the morphometric parameters of sacrum and their statistical analysis.

	Group	Number	Mean	SD	SE	Independent t - test	P – value
Length of sacrum	Female	33	89.69	3.96	0.69	13.426	< .001
	Male	40	101.45	3.52	0.56		
Breadth of sacrum	Female	33	102.21	4.82	0.84	3.542	< .001
	Male	40	98.83	3.32	0.53		
Ap diameter of s1	Female	33	29.08	1.18	0.21	1.522	0.132

vertebrae	Male	40	29.49	1.11	0.18		
Transverse diameter of s1 vertebrae	Female	33	44.50	2.08	0.36	3.723	< .001
	Male	40	46.16	1.72	0.27		
Length of auricular surface	Female	33	53.82	2.55	0.44	2.008	0.048
	Male	40	54.82	1.65	0.26		

Table 2: shows the various indices of the sacrum with their statistical analysis.

	Group	Number	Mean	SD	SE	Independent 't' test	p value
Sacral index	Female	33	113.90	1.74	0.30	54.631	< .001
	Male	40	97.33	0.74	0.12		
Corporo basal index	Female	33	43.48	0.46	0.08	24.530	< .001
	Male	40	46.63	0.61	0.10		
Index of the body of s1 vertebrae	Female	33	66.09	0.82	0.14	18.805	< .001
	Male	40	63.04	0.56	0.09		
Auricular index	Female	33	52.61	0.49	0.09	14.638	< .001
	Male	40	55.44	1.02	0.16		

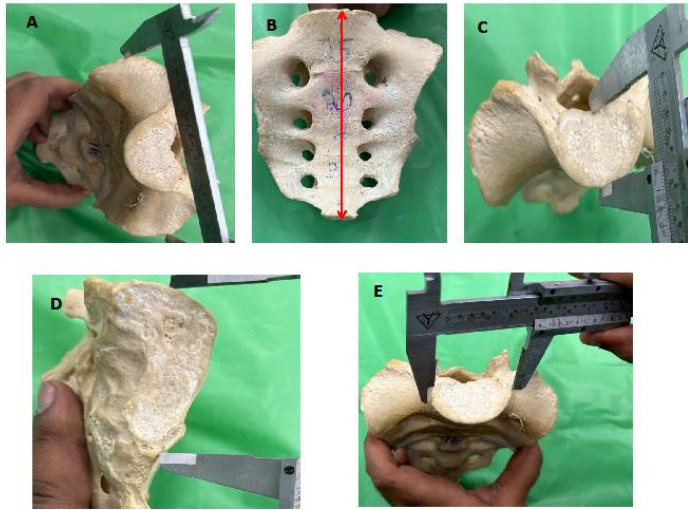


Figure: 1 A) Shows maximum width of the sacrum B) Shows maximum length of the sacrum C) Shows anteroposterior diameter of S1 vertebrae D) Shows maximum length of auricular surface E) Shows transverse diameter of S1 vertebra.

DISCUSSION

Length of the sacrum- In our study the mean length of the sacrum in male gender is (101.45 ± 3.52) and in female gender (89.69 ± 3.96)

To our comparison between female and male sacra revealed that the average length of the female sacra was smaller than that of the male sacra which denotes significant sexual dimorphism present in sacral dimensions. According to the study conducted by [Mishra et al, (7)] involving the population of Agra, in India, recorded a mean sacral length to be 107.53mm in males and 90.58 mm in females. Study by [Kanika et al, (8)] focused on North India, found the mean sacral length in males to be 104.1 mm and 91.8 mm for females. This contrasts with the study conducted by [Jyothinath K et al (9)] which reported a lesser length in males and greater length of the sacrum in females. Additionally studies conducted by [AK Arora et al (10) from Punjab, Anil Kumar et al (11), Shailendra Patel et al (12) from Madhya Pradesh, Bindra GS and Mohan.A et al from Haryana (13), Arpan Dubey et al (14), Kataria et al from Rajasthan (15), Parashuram R et al (16)] aligned more closely with our studies.

Width of the sacrum- In our study the mean breadth of the sacrum in male gender was 98.83 ± 3.32 and in female gender it was 102.21 ± 4.82 . Study conducted by [Mishra SR et al (7)] carried out in the Agra region, concluded that there was no significant difference in the sacral width between males and females. This contrasts with the study conducted by [Kanika et al (8)] involving the population of North India and found average sacral width of 103.1mm in males and 101.7mm for females. Additionally, studies conducted by [Maddikunta.V et al (17), Shwetha Asthana et al (18), A K, Arora et al (10), Arpan Dubey et al (14), Shailendra et al (12), Anil Kumar et al (11)] aligned more closely with our studies.

Transverse diameter of body of 1st sacral vertebra – In our study, the transverse diameter of the body of 1st sacral vertebra in male gender was 46.16 ± 1.72 and in female gender it was 44.50 ± 2.08 . In our study the mean transverse diameter of body of S1 vertebra is more in males when compared to females. The study conducted by [Raju and singh et al (19), Anil Kumar et al (11), Mishra et al (7), Madikunta V et al (17)] demonstrated similar results.

Anteroposterior diameter of first sacral vertebra – In the present study the mean AP diameter of S1 Vertebra in male gender is 29.49 ± 1.18 and in female gender 29.08 ± 1.11 . In our study the mean AP diameter of body of S1 vertebra is more in males when compared to females. Our findings were similar with those reported by [Mishra et al (7)] who recorded average AP diameter in males 30.03 and 29.29 in females. [Raju and singh et al (19)] found 30.03 in males and 27.63 in females. [Anil Kumar et al (11)] found 30.6 mm in male and 30.5 mm in female.

Mean length of Auricular surface- In the present study the mean length of auricular surface in male gender is 54.82 ± 1.65 and in female gender 53.82 ± 2.55 . In our study mean length of auricular surface is more in males when compared to females. Studies done by [Binod Kumar et al (20) and, Mishra et al (7)] demonstrated similar results.

Mean sacral index – In the present study the mean sacral index in male gender is 97.33 ± 0.74 and in female gender it is 113.90 ± 1.74 . In our study we observed the mean sacral index is more in females when compared to males. Our study findings align closely with a similar study by [Binod Kumar et al (20), Madikunta V et al (17), Arpan Dubey et al (14), Shwetha Asthana et al (18), Shailendra patel et al (12), Anil Kumar et al (11), Mishra et al (7), Kataria et al (15)]

Corporobasal index – In the present study the mean corporobasal index in male gender is 46.63 ± 0.61 and in female it is 43.4 ± 0.46 . The mean value for male is higher than female. The findings of present study agree with the findings of [Mishra et al (7), and Mazumdar S et al (21)]

Index of the body of S1 vertebra – In the present study the mean index of the body of S1 vertebra in male gender is 63.04 ± 0.56 and in female gender it is 66.09 ± 0.82 . The findings of the present study are similar with findings of [Smita et al (22)] where index of the body of S1 vertebra in male was 69.74% and in females 72.40% and our findings were also similar with the findings of [Raju et al (19)]

Auricular Index - In the present study the mean Auricular index in male gender is 55.44 ± 1.02 and in female gender it is 52.61 ± 0.49 . The mean auricular index more in males than females was observed by [Mishra et al (7)] and the difference was statistically significant. The mean auricular index was also more in male than in female as observed by [AHM Mostafa Kamal et al (23)]

CONFLICT OF INTEREST – None

CONCLUSION – Corporobasal index, index of the body of S1 vertebra, auricular index is greater in male sacrum when compared to female, but there was no significant difference. Sacral index was significantly more in females than males.

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