SIGNIFICANCE OF SACRAL INDEX IN ESTIMATION OF SEX OF SACRUM IN CENTRAL RAJASTHAN

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ABSTRACT

BACKGROUND

Anatomists, anthropologists and forensic experts judge the sex of the skeletal material by non-metric observations. Sex-dependent differences have been noted in the pelvic bone anatomy, and so differences exist in male and female sacrum. Over the years, different authors had carried various types of measurements on human sacra of different races. The well-known method for determination of sex of sacrum has always ideally been the Sacral Index method as explained in the Hrdlicka's Practical Anthropometry. The formula for Sacral Index is: $\text{Sacral Index} = \frac{\text{Width of Sacrum} \times 100}{\text{Length of Sacrum}}$.

The aim of this study was to collect data regarding morphometric measurements of maximum length and breadth of sacrum and to find out possible variations of sacral index in different individuals in relation to sex.

MATERIALS AND METHODS

A descriptive study was conducted in the Department of Anatomy, Govt. Medical College, Kota on 75 (seventy-five) adult human dry sacra of unknown sex. The sacral bones were distributed into male (40) and female (35) groups by discriminant functional analysis. The study sample was studied morphologically for sacral length and sacral breadth with digital sliding Vernier caliper.

RESULTS

The mean sacral index in male and female were $97.88 \pm 6.16\%$ and $112.69 \pm 10.17\%$ respectively. Female has the greater sacral index than male ($P < 0.001$).

CONCLUSION

The bones of the body are the last to pass away after death, next to enamel of teeth. Medico-legal experts, anatomists and anthropologists use the skeletal materials for giving their opinion in respect to sex, age and stature for establishing the personal identity. Sacral index method is relevant and significant for determination of sex.

KEYWORDS

Discriminant Function Analysis, Gender, Sacral Index, Sex Determination, Sacrum.

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BACKGROUND

Determination of sex is an integral part and first step in the development of the biological profile in human osteology. Establishing the identity of the human remains is one of the most important and challenging. Anatomical variations occur frequently in the lower region of the vertebral column making the sacrum the most variable portion of the vertebra. The variation may be attributed to the dependency of the final sacral morphology to the load-related fusion of the bony structures. Developmental malformation may occur as well. Forensic expert and anatomist have to give their opinion for the unknown and mutilated dead body. It was by Taylor in his book of medical jurisprudence that the accuracy of estimating the sex from skeletal remains depends upon number of bones available.¹

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Skull and Femur 97.35%, Coccyx and Sacrum 97.18%, Pelvis 95%, Skull alone 91.38%, Femur 39.84%, Atlas vertebra 31.18%. The high accuracy of sex assessment (88.3%) by the discriminant analysis of the sacral base is a valid method of estimating the sex of skeletal remains from a range of populations. The sacrum is a large, triangular, irregular type of bone, situated in the lower part of the vertebral column where it is inserted like a wedge between the two hip bones.² Sacrum meaning 'Temple' in Greek and 'Sacred' in Latin is a large vertebral bone housing all the caudal spinal nerves.³ The geometry of sacral length and breadth also varies among different populations leading to variations in average sacral index.^{1,4} Anatomists, anthropologists and forensic experts judge the sex of the skeletal material by non-metric observations. Sexual divergence has been based upon actual measurements in different bones. There is paucity of metrical data available for sacral bone.^{1,5} Sex differences exist in the male and female sacrum.⁶ The sacrum can be used for sexual dimorphism as in anthropological work. The well-known method for determination of sex of sacrum has always ideally been the Sacral Index method as explained in the Hrdlicka's Practical Anthropometry.^{7,8}

The Formula of Sacral Index is-

$\text{Sacral Index} = \frac{\text{Width of Sacrum} \times 100}{\text{Length of Sacrum}}$.

The aim of the present study is to determine the significance of sacral index in sex determination and compares the finding with different races according to the literatures available.

MATERIALS AND METHODS

A descriptive study was conducted in the Department of Anatomy, Govt. Medical College, Kota on 75 (seventy-five) adult human dry sacra of unknown sex. The sacral bones were distributed into male (40) and female (35) groups by discriminant functional analysis, i.e. is a statistical analysis to predict a categorical dependent). The study sample was studied morphologically for sacral length and sacral breadth with digital sliding Vernier caliper.

Figure 1. Digital Vernier Caliper

Figure 2. Measurement of Sacral Length with Digital Vernier Caliper

Figure 3. Measurement of Sacral Breadth with Digital Vernier Caliper

Sacral index was measured by taking the breadth and length of individual sacrum with the help of Vernier Digital Caliper and adopting the method as demonstrated in Hrdlicka's Practical Anthropometry.^{7,8} The stem of caliper was applied to upper surface of the body of first sacral vertebra and measurement of maximum breadth was taken across the greatest expanse of lateral masses of the bone as shown (Figure 1, 2 and 3).

A total of 75 (seventy-five) dried, completely ossified, grossly normal adult human sacra of unknown sex were assessed. The sacra were collected from Department of Anatomy of Govt. Medical College, Kota. The study samples were distributed in male and female sex groups by discriminant function analysis. With the help of digital Vernier calipers, different measurements were recorded in millimetres. Measurement of maximum length of sacrum was recorded by the distance from antero-superior margin of promontory to the middle of antero-inferior margin of the last sacral vertebra. Maximum breadth of sacrum was measured by taking two points at the upper part of auricular surface anteriorly.

The sacral index (SI) is calculated with the formula:

$$\text{Sacral Index} = \frac{\text{Width of Sacrum} \times 100}{\text{Length of Sacrum}}$$

Differences between length and breadth done by paired student's 't' test and comparison between sex done by unpaired student's 't' test.

P-value < 0.05 was considered statistically significant.

Ethical Clearance

This study was approved by the Ethical Review Committee of Govt. Medical College, Kota.

RESULTS

The mean length of sacrum in male and female was 107.44 ± 6.95 mm and 91.65 ± 7.03 mm respectively and the mean breadth of sacrum in male and female was 104.63 ± 6.41 mm and 102.77 ± 6.57 mm respectively. Sacral index in male and female is $97.88 \text{ SD} \pm 6.16$ and $112.69 \text{ SD} \pm 10.17\%$ respectively.

In case male sacral length is greater than breadth and opposite was found in female i.e. breadth is greater than length ($P < 0.001$) (Table 1).

Sacral Length in Male (MMS)	Sacral Breadth in Male (MMS)	Sacral Index in Male	Sacral Length in Female (MMS)	Sacral Breadth in Female (MMS)	Sacral Index in Female
107.44 SD±6.95	104.63 SD±6.41	97.88 SD±6.16%	91.65 SD±7.03	102.77 SD±6.57%	112.69 SD±10.17%

Table 1. Length and Breadth of Sacrum in Male and Female

	Sacrum Length	Sacrum Breadth	Mean ± SD Value	P value
Male (N=40)	107.44 SD±6.95	104.63 SD±6.41	107.44±6.95	<0.001
Female (N=35)	91.65 SD±7.03	102.77 SD±6.57%	91.65±7.03	<0.001

Table 2. Sex-Wise Length (mm), Breadth (mm), Mean ± SD, Minimum-Maximum, P value

Differences between length and breadth done by paired student's 't' test and comparison between sex done by unpaired student's 't' test was significant (Table 2).

Mean sacral index in male and female were $97.88 \pm 6.16\%$ and $112.69 \pm 10.17\%$ respectively.

Female has the greater sacral index than male ($P < 0.001$).

DISCUSSION

In present study, mean sacral index is found to be higher than Indians of Tamilnadu and Andhra and of Bengal and lower than Australians and of white Americans and black

Americans and Haryana and UP region. In female, values is found to be more than Indians of Bengal and Tamilnadu and Andhra, but lower than Australians and Americans. Similarly, variations in sacral breadth and sacral index were also observed as shown in (Table 3).

These observations are in accordance with those of Davivongs in Australia's aborigines and Flander in American-Blacks.

Flander used univariate and multivariate analysis method for sex determination of sacrum.

		Mean Male Sacral Length	Mean Male Sacral Breadth	No. of Sacrum	Mean Female Sacral Length	Mean Female Sacral Breadth	Mean Sacral Index Male	Mean Sacral Index Female
Davivongs (1963) ⁴ Australian Aborigine		96.5±0.88	88.1±0.687	100	99.9±0.5	101.2±0.51	104.16±8.93	115.49±10.39
Flander (1978) ⁹	White Americans	-	-	100	-	-	106.49±10.4	108.69±13.59
	Black Americans	-	-	100	-	-	106.17±10.36	112.35±11.03
Mishra SR et al (2003) ¹ Agra (UP)		107.53±7.03	90.58±4.42	116	105.34±6.222	105.16±6.322	98.21±4.89	117.84±7
Math SC ¹⁰ MM (2006)		117.00	104.20		86.00	106.30 mm	94.24%	113.19%
Patel MM (2006) ⁷ (Gujrat)		-	-	64	-	-	90.5 – 106% Mean 96.25%	104.8 – 131% Mean 113.25%
Arora AK et al (2010) ¹¹ (Punjab)		109.74±11.66	91.22±6.348	40	101.44±8.96	114.13±9.67	93.69±11.57	125.35±11.47
Sachdeva K et al (2011) ¹² (Punjab)		104.1±1.26	91.8±0.71	50	103.1±0.78	101.1±0.7	100.24±12.54	111.14±14.6
Mazumdar S et al (2012) ¹³ (Indian Bengal)		100.8±11.5	87.3±7.4	250	96.3±7.4	95.6±5.7	94.9±4.8	109.8±7.3
Ravichandran D (2013) ¹⁴ (Tamilnadu and Andhra)		97.8	93.7	123	90.96	92.91	96.32±5.40	102.29±4.0
Bindra et al (2015) ¹⁵ Indians (Haryana Region)		106.85	90.89	60	108.24	106.87	101.3	117.56
Yadav N et al (2015) ¹⁶ Indian (Maharashtra)		104.7±5.94	102.93±4.83	140	92.6±6.1	104.77±6.48	98.44±4.69	113.23±5.61%
Present Study (2017) (Central Rajasthan)		107.44 SD±6.95	104.63 SD±6.41	75	97.88	102.77 SD±6.57%	97.88 SD±6.16%	112.69 SD±10.17%
Table 3. Comparative Study of Sacral Index by Different Authors in Different Population								

Mishra et al¹ examined 116 adult human dry sacra (74 males and 42 females) of Agra region and showed that mean length was greater in male (107.53 ± 7.03 mm) than female (105.34 ± 6.222), which was similar to the present study. Math¹⁰ described that ventral straight length in male was 117.00 mm and that for female was 86.00 mm. Mean length of male sacra was significantly higher than in female, which was similar to the present study. The mean ($\pm$ SD) breadth of

sacrum in present study in male and female was $107.44 \text{ SD} \pm 6.95$ mm and 102.77 ± 6.57 mm respectively are similar to the findings of Arora.¹¹ Our reading is higher than Davivong et al⁴ in Australian aborigine.

Math¹⁰ described that width of sacrum in male was 104.20 mm and that for female was 106.30 mm. He also described that sacrum with maximum length measuring

above 117.00 mm is definitely a male and below 86.00 mm is definitely a female.

Arora¹¹ examined sacra of Punjab region and showed that maximum breadth of male sacrum was 91.22 ± 6.348 mm and in female was 114.13 ± 9.67 mm. The mean breadth of sacrum in male in present study was similar to the values reported by Math¹⁰ and almost equal to Yadav et al,¹⁶ but higher than Mishra et al,¹ Mazumdar et al,¹³ Bindra et al¹⁴ and Ravichander et al.¹⁴

The mean sacral index in male and female in present study are $97.88 \pm 6.16\%$ and $112.69 \pm 10.17\%$ respectively. Female has the greater sacral index than male and the difference was statistically highly significant (< 0.001). Our study was similar to Patel,⁷ who had reported the range of sacral index for males as 90.5 - 106% (Mean sacral index was 96.25%) and in case of females, sacral index was 104.8 - 131% (Mean sacral index was 113.25%). Sacral index according to Davivong et al⁴ in Australian aborigine is higher in both male and female than present study.

Our present study is similar to Math,¹⁰ Arora et al⁷ and Mazumdar et al¹³ who had reported average value for sacral index in male were 94.24% and for females were 113.19% in Yadva N et al¹⁶ of Maharashtra, but lower than Sachdeva et al¹² and Bindra et al¹⁵ in Haryana.

Flander¹² reported the average sacral index in white males was 106.49 and in white female was 108.69. In blacks, he reported the average was 106.17 in males and 112.35 in females. Thus, from the above discussion, it is clear that the average sacral index varies among different populations.

Thus, present study clearly indicates the presence of racial and regional differences in sacrum, especially length parameters and sacral index methods can be used as an effective method of sex determination of sacrum.

CONCLUSION

Since sacrum is a part of the pelvic girdle with functional differences between the two sexes, sacrum is important for identification of sex of human skeletal system. Sexing of sacrum by sacral index method is relevant and significant. The average sacral index identified in the present study would be of use to forensic experts, anthropologists and anatomists of central part of Rajasthan. We recommend future studies with larger sample size. Such studies will also be useful to observe the changing trends if any in the metric measurement which is influenced by environmental, socioeconomic factors, physical stress and genetic factors.

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