Original Article

Dimensions of Sacrum Show Sexual Dimorphism

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Abstract

Background: Study of skeletal remains of the unknown decomposed body plays a vital role for establishing the identity of the subject. Sexual dimorphism is found in the different parameters of sacra, which varies within and between the worldwide populations.

Materials and Methods: A cross-sectional descriptive study was conducted among 100 dry adult human sacra from January 2023 to June 2024, Department of Anatomy, TMSS Medical College and Shaheed Ziaur Rahman Medical College, Bogura. Data were collected by using a pre-designed questionnaire prepared for the study. Sex determination was done by using discriminant function analysis (DFA) and found 43 male and 57 female sacra.

Results: The straight length and ventral curved length of sacrum was found to be significantly greater in male than females ($p<0.000$). The breadth of sacra was found significantly greater in females compared to male ($p=0.001$). The sacral index was significantly less in male (94.45 ± 4.98%) compared to females (109.84 ± 8.80 %) ($p<0.000$). The curvature index was significantly more in male (95.00 ± 4.79 %) compared to females (91.72 ± 4.24 %) ($p=0.000$).

Conclusion: This study findings can provide a baseline data for morphometric sex differences in the sacra of northern region of Bangladesh. The length of sacra and curvature index were greater in male; but the breadth of sacra and sacral index were greater in female; whereas different other morphometric parameters do not differ significantly.

Keywords: Human sacrum, Morphometry, Sexual dimorphism.

Introduction

Determination of the sex of the unknown decomposed body is necessary to determine age, ancestry and stature estimations. Sexual dimorphism is found in the dimensions of sacra, which differs within and between the populations. These differences allow the development of discriminant functions which reduce the subjectivity of sexual diagnosis from morphologic traits.[1] The discriminant function is population specific and differs with race and geographical location[1, 2].

The sacrum, a large triangular bone formed by fusion of five sacral vertebrae, lies in the central part of the postero-superior wall of the pelvic girdle. It supports the erect spine and provides the strength and stability of the bony pelvis to transmit the body weight and also allows considerable mobility in childbearing.[3] The anterior and upper margins of the body of the first sacral vertebra bulge forward as the posterior margin of the pelvic inlet called sacral promontory, which is an important obstetric landmark used when measuring the size of the pelvis.

In general, the sacrum in male is larger than that in females except at the breadth is larger in females.[4, 5] Existing forensic standards are often derived from/ Western cohorts, raising concerns about their. generalizability to Bangladeshi populations due to the interpopulation variability in different sacral parameters. The present study was undertaken to study the morphometric analysis of sacrum and also the sex

differences in the sacra to provide a baseline data for the northern region of Bangladesh.

Materials and Methods

For this study sacra were collected from the Department of Anatomy, TMSS Medical College and Shaheed Ziaur Rahman Medical College, Bogura. Data were collected by using a pre-designed questionnaire prepared for the study during the period from January 2023 to June 2024. Grossly malformed sacrum or incomplete sacrum were excluded. Lumbarization and sacralization would affect the measurements of normal sacra.

With the help of digital slide calipers different measurements were done and recorded to the nearest millimeter. Only the curved measurement of sacrum was recorded using flexible ribbon tape. Sex determination of the collected unknown sacra were done by using statistical analysis SPSS version 29.2.0(20) following discriminant function analysis formula according to criteria set by Gapert 2009.[6,7] The study was approved by the Institutional Ethical Committee, and informed consent was obtained from the subjects.

1. **Maximum length:** was measured along the mid-line of sacrum with the sliding caliper from middle of promontory to middle of antero-inferior margin of the last sacral vertebra in millimeters.[8]
2. **Curved length:** it was measured along the midline of the promontory to middle of antero-inferior margin of the last sacral vertebra by the flexible tape.[8]

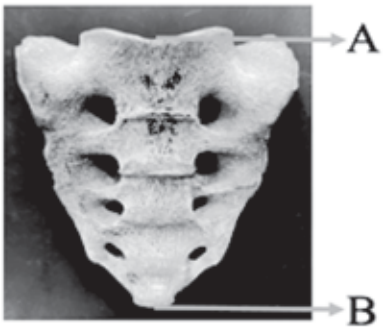

Figure 1: Photograph showing measurement of sacral maximal length (distance between A and B).

3. **Maximum breadth:** It was measured by taking two points at the lateral most part of ala of sacrum.[8]

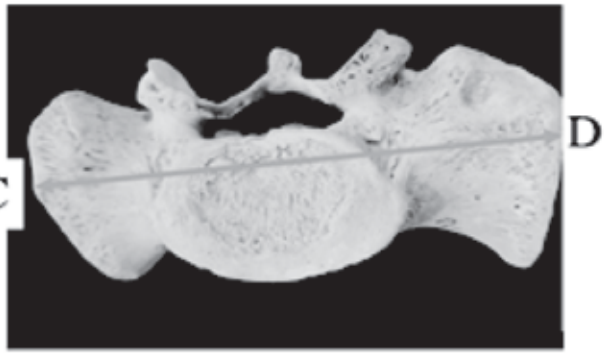

Figure 2: Photograph showing measurement of sacral maximal breadth (distance between C and D).

Sacral index was calculated and recorded with the formula, 'Sacral index = breadth x 100 / straight length.[9,10]

Curvature index was calculated and recorded with the formula, 'Curvature index =straight length xl00/ ventral curved length. [9,10]

Results

Table I: Maximum Length, breadth and sacral index of male and female sacra (male=43, female=57)

Variables	Sex	Measurement		P value
		Range	Mean ±SD	
Length (mm)	Male	88.19-118.00	106.03±6.91	0.000(S)
	Female	76.57-113.30	95.47±8.87	
Breadth (mm)	Male	83.46-113.41	100.01±6.75	0.001 (S)
	Female	91.03-119.30	104.31±6.28	
Sacral Index (%)	Male	77.56-100.28	94.45±4.98	0.000 (S)
	Female	99.40-145.88	109.84±8.80	

***P values reached from unpaired 't' tests, Results are shown as mean ±SD, S=significant**

Table I: shows the mean length of sacrum in male and female were 106.03±6.91mm and 95.47±8.87 mm respectively and the mean breadth of sacrum in male and female were 100.01±6.75 mm and 104.31±6.28 mm respectively. In the case of male, length of sacrum

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was significantly greater than female (P=0.000) and opposite was found in females where breadth was significantly greater than male (P=0.001).

The mean sacral index in male and female were 94.45±4.98 and 109.84±8.80 respectively. The value of sacral index in female was significantly greater than male (P=0.000).

Table II: Ventral curved length and curvature index of sacrum (male=43, female=57)

Variables	Sex	Measurement		P value
		Range	Mean ±SD	
Ventral curved length (mm)	Male	95.00-126.00	111.72±6.67	0.000 (S)
	Female	82.00-128.00	104.18±9.41	
Mid curved breadth (mm)	Male	70.10-90.00	80.02±5.25	0.402 (NS)
	Female	62.92-97.64	80.32±6.59	
Curvature index (%)	Male	78.58-107.27	95.00±4.79	0.000 (S)
	Female	81.93-98.94	91.72±4.24	

*P values reached from unpaired 't' tests, Results are shown as mean ±SD, S=significant, NS= non- significant

Table II shows regarding the ventral curved length, it was 111.72±6.67 mm and 104.18±9.41 mm in male and female respectively; whereas dorsal mid curved length was 124.77±12.88 mm and 116.18±18.15 mm. Male had a significantly greater value than females in both cases (P=0.005 and P=0.003 respectively). Irrespective of sex the ventral curved length was greater than that of the straight length of sacrum.

The mean± SD mid ventral breadth of sacrum in male and female was 80.02±5.25 mm and 80.32±6.59 mm respectively, the difference between two groups was not statistically significant.

It is noteworthy that the curvature index was calculated by straight length of sacrum×100/ventral curved length. The mean value of curvature index in male was found 95.00±4.79 and in females was 91.72±4.24. The mean value of the curvature index was significantly greater in male than female (P=0.000).

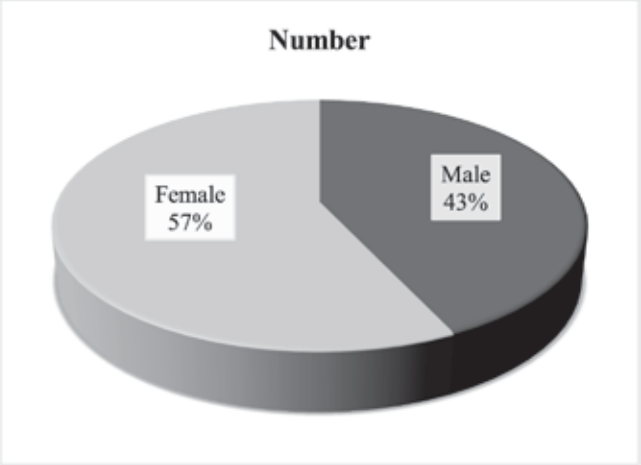

Figure 3: Pie diagram showing distribution of male and female sacra.

Discussion

Skeletal measurements vary widely among populations due to the genetic and environmental factors, food habits and many other factors. Considering the regional variability, each population should have specific standards and baseline data to optimize the accuracy of identification. So, the present work was undertaken to study various morphometric variables for determination of sex in the northern region of Bangladesh. The findings of this study were statistically analyzed and compared with that of different authors and researchers of home and abroad.

In this study, sex determination of the collected unknown sacra were done by using discriminant function analysis formula according to criteria and other sex differentiating features of sacra set by Gapert, (2009)[6] and Dhamnetiya et al (2022).[11]

Discriminant Function Analysis (DFA) is a popular method for determination of sex from skeletal remains. Luo (1995)[12] (cited by Gomez-Vades 2011)[13] studied the North-American population from the Human Identification Library of the University of Arizona and found that 100% of the 230 individuals evaluated were accurately sexed, using discriminant function analysis with direct and indirect pubis measurements. He stated that DFA offers several advantages because it is inherently more objective, with greater reliability. So,

in the present study, all the indexes were tested by discriminant function and similar results were observed for determination of sex.

The mean length of sacrum in male and female were 106.03±6.91mm and 95.47±8.87 mm respectively and the mean breadth of sacrum in male and female were 100.01±6.75 mm and 104.31±6.28 mm respectively. In the case of male, length of sacrum was significantly greater than female (P=0.000) and opposite was found in females where breadth was significantly greater than male (P=0.001). Naznin RA (2018)[14] found the mean length of sacrum in male and female were 107.55 ± 8.89 mm and 93.64 ± 6.93 mm respectively; the length of sacrum was significantly greater in male than female (p<0.001). This result correlated with the study of Ahankari et al., (2016) [8] where they found the mean length of sacrum in male and female were 107.41 ± 5.62 mm and 92.57 ± 8.51 mm respectively; the length of sacrum was significantly greater in male than female (p<0.001). This result was also consistent with the study of Kamal et al., (2013) [7] that the mean length of sacrum in male and female were 107.44 ± 6.95 mm and 91.65 ± 7.03 mm respectively; the length of sacrum was significantly greater in male than female (p<0.001). Yadav et al., (2015)[15] also found that the mean length of sacrum in male and female were 104.73 ± 5.94 mm and 92.64 ± 6.10 mm respectively; the length of sacrum was significantly greater in male than female (p<0.001).

Again, Naznin RA (2018)[14] found the mean breadth of sacrum in male and female were 101.52 ± 6.81 mm and 106.15 ± 5.07 mm respectively; the mean breadth was significantly greater in female than that in male (p=0.007). This result was supported by Rahman, (2016)[16] that mean breadth of sacrum in male and female were 103.94 ± 5.53 mm and 105.50 ± 5.59 mm respectively; the mean breadth was significantly greater female than male (p=0.037). This result was also supported by Arora et al., (2010)[17] that mean breadth of sacrum in male and female were 101.94 ± 8.96 mm and 114.13 ± 9.67 mm respectively; the mean breadth was significantly greater in female than male (p=0.0002). Yadav et al., (2015)[15] found that the mean breadth was significantly greater in females (104.77 ± 6.48) than male (102.93 4.83) but did not reach the level of significance (p=0.057). Ahankari et al., (2016)[8] reported similar results (p>0.05).

Regarding the ventral curved length, it was 111.72±6.67 mm and 104.18±9.41 mm in male and female respectively, whereas dorsal mid curved length was 124.77±12.88 mm and 116.18±18.15 mm. Male had a significantly greater value than female in both cases (P=0.005 and P=0.003 respectively). Irrespective of sex the ventral curved length was greater than that of the straight length of sacrum. This result was in accordance with the study of Naznin RA (2018),[14] she found the mean ventral curved length of sacrum was 113.40 ± 7.91 mm in male and was 103.87 ± 9.60 mm in female; the ventral curved length of sacrum was significantly greater in male than female (p<0.001). Rahman, (2016)[16] also found that the mean ventral curved length of sacrum was 111.85 ± 8.63 mm in male and was 110.29 ± 8.92 mm in female; the ventral curved length of sacrum was significantly greater in male than female (p=0.001). This result also correlated with the study of Ahankari et al., (2016)[8] where they found that the mean ventral curved length of sacrum was 116.48 ± 5.93 mm in male and was 110.89 ± 7.80 mm in female; the ventral curved length of sacrum was significantly greater in male than female (p<0.001).

Present study revealed, sacral index was significantly less in male (94.45 ± 4.98%) compared to females (109.84 ± 8.80 %) (p<0.000). Likewise, Naznin (2018)[14] stated the mean sacral index in male and female was 92.70 ± 5.68 percent in male and was 111.10 ± 6.85 percent in female; the mean sacral index was significantly more in female compared to male (p<0.001). This result was consistent with the study of Mazumdar et al., (2012)[18] where they found that the mean sacral index was 94.9 ± 4.8 percent in male and was 109.8 ± 7.3 percent in female; the mean sacral index was significantly lower in male compared to female (p<0.0001). This result was also in agreement

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with the study of the study of Biju GV, (2022)[19] that the mean sacral index was 97.30 percent in male and was 116.64 percent in female; the mean sacral index was significantly lower in male compared to female ($p<0.001$). Several other studies also supported this result (Ravichandran et al., 2013[20]; Kamal et al., 2013; Shreekrishna et al., 2013[10]; Kumar et al., 2021[21]; Yadav et al., 2015[15]; Rahman, 2016)[16].

The study of Naznin (2018)[14] stated that mean **curvature index** in male and female was 96.07 ± 4.78 percent in male and was 93.31 ± 5.51 percent in female; the mean curvature index was significantly more in male compared to female ($p=0.007$). The present study shows the curvature index was significantly more in male (95.00 ± 4.79 %) compared to females (91.72 ± 4.24 %) ($p=0.000$). This result was similar to the study of the study of Rahman, (2016)[16] where they found that the mean curvature index was 94.96±3.72 percent in male and was 91.41 ± 4.99 percent in female; the mean curvature index was significantly more in male compared to female ($p=0.0001$). This findings was also supported by Shreekrishna et al., (2013)[10] that the mean curvature index was 94.72 ± 1.91 percent in male and was 91.2 ± 5.19 percent in female; the mean curvature index was significantly more in male compared to female ($p=0.001$).

The sacrum is a highly variable bone, though it varies according to sex, but also varies with race and body size. For more accuracies some authors used 3D geometric morphometrics[22] and ROC curve evaluation[23] to find out the most reliable parameters for sex estimation. There few studies especially focused on anatomical properties of related structures in healthy individuals using MRI[24] or Multi Detector Computed Tomography (MDCT) images. Future studies involving larger and more diverse samples, as well as longitudinal imaging data, can provide more refine and validate findings.

Conclusion

Since sacrum forms the central part of the pelvic girdle with functional differences between male and females, it itself becomes important for identification of sex in the human skeletal system. This study provides a baseline data for morphometric sex differences in the sacra of northern region of Bangladesh. Further study with a large number of known sex samples and more technical involvement is recommended.

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Limitation

The study was carried out on sacra collected from different medical colleges of Bogura, within limited time and no sophisticated technology was used.

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