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Determination of Sex by Morphometric Study of Dry Adult Human Sacrum

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Abstract

Background: *Identification of human skeletal remains is a critical problem and is very important in medico legal and anthropological work. Sacrum is one of the last bones to pass away after death and forms an important source of information about sexual dimorphism. The present study was conducted to observe the morphometric measurements of human dry sacrum to establish the possible sex of an individual.*

Materials and Methods: *This study was performed on 60 dried completely ossified, grossly normal adult sacra of unknown sexes fulfilling the inclusion criteria from the stocks of Anatomy laboratory of Sylhet MAG Osmani Medical College, Sylhet from July 2017 to June 2018. Sex determination of the collected unknown sacra was done by using discriminant function analysis and found 30 (50.0%) male and 30 (50.0%) female. By using digital slide calipers and measuring tape different parameters were measured.*

Results: *The length of sacrum was significantly greater in male (107.55 ± 8.89 mm) than female (93.64 ± 6.93 mm) (p<0.001). The breadth of sacrum was significantly greater in female (106.15 ± 5.07 mm) compared to male (101.52 ± 6.81 mm) (p=0.007). The ventral curved length of sacrum was significantly greater in male (113.40 ± 7.91 mm) compared to female (103.87 ± 9.60 mm) (p<0.001). The antero-posterior diameter and transverse diameter of the body of first sacral vertebra did not differ significantly between male and female (p>0.05). The length of the ala of both right and left side did not differ significantly between male and female (p>0.05). The mean antero-posterior diameters of ala of the body of first sacral vertebra of both right and left side did not differ significantly between male and female (p>0.05).The length of sacral auricular surface of right and left side did not differ significantly between male and female (p>0.05).The anterior transverse curvature of pelvic surface of sacrum at the level of S2 and S3 was significantly more in female (81.30 ± 9.60 mm) compared to male (77.47 ± 6.03 mm) (p=0.022). The anterior transverse curvature of pelvic surface of sacrum at the level of S3 and S4 did not differ significantly between male (67.93 ± 7.12 mm) and female (66.40 ± 6.06 mm) (p=0.373). The sacral index was significantly less in male (92.70 ± 5.68 percent) compared to female (111.10 ± 6.85 percent) (p<0.001). The curvature index was significantly more in male (96.07 ± 4.78 percent) compared to female (93.31 ± 5.51 percent) (p=0.007). The index of body of S1 did not differ significantly between male (60.00 ± 6.35 percent) and female (61.81 ± 6.87 percent) (p=0.293). The corporo-basal index did not differ significantly between male (47.75 ± 6.11 percent) and female (45.29 ± 4.04 percent) (p=0.070). The alar index did not differ significantly between male (71.38 ± 10.72 percent) and female (75.73 ± 9.68 percent) (p=0.105). The auricular index was significantly more in male (72.65 ± 7.93 percent) compared to female (67.77 ± 8.73 percent) (p=0.027).*

Conclusion: *The length, curvature index and auricular index of sacrum are greater in male; but the breadth of sacrum, anterior transverse curvature of pelvic surface of sacrum at the level of S2 and S3 and sacral index was greater in female; where as differences of other morphometric parameters are not significant.*

Key words: *Determination of sex, sacrum*

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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]In the determination of personal individuality from adult human skeletal remains, the pelvis affords the best marked and reliable characteristics for distinguishing sex in 90% - 95% subjects.[2] Bony Sacrum is a large triangular bone formed by fusion of five sacral vertebrae located in the caudal region of the vertebral column & it forms the postero-superior wall of the pelvic cavity. It has been chosen by various medico legal investigators in the past for sex determination and associated sexual differences.[3]Davivongs[4] pointed out that as a general rule male bones are more massive and heavier than female bones. The female sacra are shorter and wider, providing a wider pelvic cavity.[5] Males show a narrower sciatic notch with an acute angle, the acetabulum large and the pubis short with a narrower subpubic angle. In contrast, the female pelvis shows a wider sciatic notch with an obtuse angle. It has a preauricular sulcus, a smaller acetabulum, a longer pubis, and a wide subpubic angle.[6]Thus sacrum assumes applied importance in determining sex with the help of measurements carried upon it.[3]Many researchers have emphasized the need for population specific data for methods which are based on measurements, as there are vast differences in body size in various populations.[7]

Therefore, the present study was conducted on the sacra of Bangladeshi population to observe the gender differences.

Materials and Methods

This study was performed on 60 dried completely ossified, grossly normal adult sacra of unknown sexes fulfilling the inclusion criteria from the stocks of Anatomy laboratory of Sylhet MAGOsmani Medical College, Sylhet from July 2017 to June 2018. Sex determination of the collected unknown sacra was done by using discriminant function analysis and found 30 (50.0%) male and 30 (50.0%) female. By using digital slide calipers and measuring tape different parameters were measured.

Procedure of studying the morphological variables

With the help of digital slide calipers different measurement was recorded to the nearest millimeter. Only the curved length of sacrum (Mid-ventral curved length) and anterior-transverse curvature was recorded by using flexible ribbon tape.

Maximum length of sacrum (Wilder's mid-ventral Straight length): It was measured along the mid-line of sacrum with the sliding caliper from middle of antero-superior margin of promontory to middle of antero-inferior margin of the last sacral vertebra. It was recorded in millimeters.[8]

Maximum breadth of sacrum: It was measured with the slide caliper by taking two points at the upper part of auricular surface anteriorly (or lateral most part of alae of sacrum), thus maximum breadth is measured on anterior aspect of sacrum. It was recorded in millimeters.[8]

Curved length of sacrum (Mid-ventral curved length): It was measured along the mid line of the anterior surface of the sacrum (from middle of antero-superior margin of promontory to middle of antero-inferior margin of the last sacral vertebra) by the flexible steel tape. It was recorded in millimeters.[8]

Anterior transverse curvature of the sacrum: It was measured along the level of the second and third sacral and also at the level of third and fourth sacral vertebral articulation.[9]

Antero-posterior diameter of the body of first sacral vertebra: It was the maximum possible diameter of first sacral vertebra measured with the slide caliper by taking one point on antero-superior border and another point on the postero-superior border of first sacral vertebral body.[10]

Transverse diameter of the body of first sacral vertebra: It was the maximum transverse diameter of first sacral vertebra measured with the slide caliper by taking one point on each side of the lateral most point on the superior surface of body of first sacral vertebra. It was recorded in millimeters.[8]

Length of ala: It was measured on both sides with the sliding caliper by taking one point on lateral most point of superior surface of body of 1st sacral vertebra and another point on lateral most part of alae. The mean of the length of the two sides was taken as length of alae.[10]

Maximum length of auricular surface: It was the straight auricular length measured on lateral aspect of sacrum by means of a sliding caliper by taking one point on the upper most part of auricular surface and another point on the lower most part of auricular surface of sacrum.[8]

Antero–posterior diameter of ala: was measured with the sliding caliper by taking one point on the anterior most part of ala and another point on the posterior most part of ala of sacrum. It was recorded in millimeters.[11]

By using the above measurements, the following indices were calculated. It was recorded in millimeters.

Calculations of the indices

Sacral index was calculated and recorded with the formula, 'Sacral index = breadth x 100 / straight length'.[12]

Curvature index was calculated and recorded with the formula, 'Curvature index =straight length xl00/ ventral curved length' .[12]

Index of body of first sacral vertebra was calculated and recorded with the formula, 'Index of body of first sacral vertebra = antero-posterior diameter of the body of S1 x100/ transverse diameter of body of Sacrum' .[12]

Corporo-basal index was calculated and recorded with the formula, 'Corporo-basal index = transverse diameter of body of S1 x100 / breadth of sacrum'.[12]

Alar index was calculated and recorded with the formula, 'Alar index = length of ala x100 / transverse diameter of body of S1.[12]

Auricular index was calculated and recorded with the formula, 'Auricular index = length of auricular surface x 100 / breadth of sacrum' .[12]

Data were processed manually and analyzed with the help of SPSS (Statistical package for social sciences) Version 22.0. Quantitative data were expressed as mean and standard deviation; whereas qualitative data were expressed as frequency and percentage. Student 't' test was applied to reach the level of significance where necessary. A probability value (p) of less than 0.05 was considered statistically significant.

Ethical clearance

An approval of the research protocol was obtained from the Ethical Committee of Sylhet M.A.G Osmani Medical College, Sylhet.

Results

The length of sacrum was significantly greater in male (107.55 ± 8.89 mm) than female (93.64 ± 6.93 mm) ($p<0.001$). The breadth of sacrum was significantly greater in female (106.15 ± 5.07 mm) compared to male (101.52 ± 6.81 mm) ($p=0.007$). The ventral curved length of sacrum was significantly greater in male (113.40 ± 7.91 mm) compared to female (103.87 ± 9.60 mm) ($p<0.001$). The antero-posterior diameter of the body of first sacral vertebra did not differ significantly between male (29.12 ± 3.17 mm) and female (29.42 ± 2.67 mm) ($p=0.692$). The transverse diameter of the body of first sacral vertebra did not differ significantly between male (48.86 ± 6.72 mm) and female (48.12 ± 5.03 mm) ($p=0.631$). The length of the ala of left side did not differ significantly between male (34.47 ± 4.39 mm) and female (36.06 ± 3.99 mm) ($p=0.147$). The length of the ala of right side and left side in male revealed no significant difference ($p=0.980$); and no significant difference was found in the antero-posterior diameters of ala of right side and left side ($p=0.977$) in female. The mean antero-posterior diameters of ala of the body of first sacral vertebra of right side did not differ significantly between male (49.75 ± 5.63 mm) and female (48.11 ± 4.21 mm) ($p=0.283$). The mean antero-posterior diameters of ala of the body of first sacral vertebra of left side did not differ significantly between male (50.09 ± 5.61 mm) and female (48.04 ± 4.50 mm) ($p=0.124$). The antero-posterior diameters of ala of male of right side and left side revealed no significant difference ($p=0.817$); and no significant difference

between female of right side and of left side (p=0.955). The length of sacral auricular surface of right side did not differ significantly between male (73.15 ± 8.18 mm) and female (72.44 ± 6.88 mm) (p=0.712). The length of sacral auricular surface of left side did not differ significantly between male (73.24 ± 8.18 mm) and female (72.24 ± 7.35 mm) (p=0.623). The length of sacral auricular surface of male of right side and left side revealed no significant difference (p=0.966); and no significant difference between female of right side and left side (p=0.918). The anterior transverse curvature of pelvic surface of sacrum at the level of S2 and S3 was significantly more in female (81.30 ± 9.60 mm) compared to male (77.47 ± 6.03 mm) (p=0.022). The anterior transverse curvature of pelvic surface of sacrum at the level of S3 and S4 did not differ significantly between male (67.93 ± 7.12 mm) and female (66.40 ± 6.06 mm) (p=0.373) (Table-I).

Table-I

Comparison of morphological variables of the sacrum between male and female

Morphological variables (in mm)	Sex	Range	Mean ± SD	p-value
Length of sacrum	Male (n=30)	93.10-129.49	107.55 ± 8.89	p<0.001
	Female (n=30)	73.32-114.20	93.64 ± 6.93	
Breadth of sacrum	Male (n=30)	88.03-111.97	101.52 ± 6.81	p=0.007
	Female (n=30)	93.99-118.97	106. 15 ± 5.07	
Ventral curved length	Male (n=30)	96.00-130.00	113.40 ± 7.91	p<0.001
	Female (n=30)	80.00-118.00	103.87 ± 9.60	
Antero-posterior diameter of S1	Male (n=30)	23.87-38.41	29.12 ± 3.17	p=0.692
	Female (n=30)	22.40-33.40	29.42 ± 2.67	
Transverse diameter of S1	Male (n=30)	35.59-66.79	48.86 ± 6.72	p=0.631
	Female (n=30)	38.16-57.38	48.12 ± 5.03	
Length of ala of right side	Male (n=30)	25.27-41.42	34.44 ± 4.10	p=0.122
	Female (n=30)	26.62-44.95	36.09 ± 4.05	
Length of ala of left side	Male (n=30)	24.50-41.9	34.47 ± 4.39	p=0.147
	Female (n=30)	26.62-44.95	36.06 ± 3.99	
Antero-posterior diameters of ala of right side	Male (n=30)	39.1-60.14	49.75 ± 5.63	p=0.205
	Female (n=30)	39.88-57.49	48.11 ± 4.21	
Antero-posterior diameters of ala of left side	Male (n=30)	39.1-60.80	50.09 ± 5.61	p=0.124
	Female (n=30)	40.95-57.49	48.04 ± 4.50	
Length of sacral auricular surface of right side	Male (n=30)	60.49-85.71	73.15 ± 8.18	p=0.712
	Female (n=30)	54.85-83.53	72.44 ± 6.88	
Length of sacral auricular surface of left side	Male (n=30)	60.49-88.50	73.24 ± 8.18	p=0.623
	Female (n=30)	54.85-88.64	72.24 ± 7.35	
Anterior transverse curvature at S2 & S3	Male (n=30)	67.00-88.00	77.47 ± 6.03	p=0.022
	Female (n=30)	68.00-95.00	81.30 ± 9.60	
Anterior transverse curvature at S2 & S3	Male (n=30)	67.00-88.00	77.47 ± 6.03	p=0.022
	Female (n=30)	68.00-95.00	81.30 ± 9.60	

Table-II

Comparison of different indices of the sacrum between male and female

Different indices of sacrum (in percent)	Sex	Range	Mean ± SD	p-value
Sacral index	Male (n=30)	79.37-100.10	92.70 ± 5.68	p<0.001
	Female (n=30)	102.36-125.02	111.10 ± 6.85	
Curvature index	Male (n=30)	83.54-103.00	96.07 ± 4.78	p=0.007
	Female (n=30)	80.78-102.57	93.31 ± 5.51	
Index of body of S1	Male (n=30)	43.49-72.03	60.00 ± 6.35	p=0.293
	Female (n=30)	51.43-80.76	61.81 ± 6.87	
Corporo-basal index	Male (n=30)	32.81-59.64	47.75 ± 6.11	p=0.070
	Female (n=30)	38.80-54.66	45.29 ± 4.04	
Alar index	Male (n=30)	44.59-93.29	71.38 ± 10.72	p=0.105
	Female (n=30)	55.13-95.21	75.73 ± 9.68	
Auricular index	Male (n=30)	51.12-84.92	72.65 ± 7.93	p=0.027
	Female (n=30)	42.86-84.61	67.77 ± 8.73	

The sacral index was significantly less in male (92.70 ± 5.68 percent) compared to female (111.10 ± 6.85 percent) (p<0.001). The curvature index was significantly more in male (96.07 ± 4.78 percent) compared to female (93.31 ± 5.51 percent) (p=0.007). The index of body of S1 did not differ significantly between male (60.00 ± 6.35 percent) and female (61.81 ± 6.87 percent) (p=0.293). The corporo-basal index did not differ significantly between male (47.75 ± 6.11 percent) and female (45.29 ± 4.04 percent) (p=0.070). The alar index did not differ significantly between male (71.38 ± 10.72 percent) and female (75.73 ± 9.68 percent) (p=0.105). The auricular index was significantly more in male (72.65 ± 7.93 percent) compared to female (67.77 ± 8.73 percent) (p=0.027) (Table II).

Discussion

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[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 another study where the length of sacrum was found significantly greater in male than female (p<0.001).[14] 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 male (p=0.007). This result was consistent with other studies where the breadth of sacrum was found significantly greater in female than male.[7,11] The studies of Yadav et al[13] and Ahankari et al[8] also found that the mean breadth was greater in female than male but did not reached the level of significance.

The mean ventral curved length of sacrum was significantly greater in male than female (p<0.001) which was consistent with other studies.[8,11]

The mean antero-posterior diameter of the body of first sacral vertebra was 29.12 ± 3.17 mm in male and was 29.42 ± 2.67 mm in female; the antero-posterior diameter of the body of first sacral vertebra did not differ significantly between male and female (p=0.692). This result was supported by the study of Rahman[11] where they found that the mean the antero-posterior diameter of the body of first sacral vertebra was 28.82 ± 2.95 mm in male and was 29.62 ± 2.62 mm in female; the antero-posterior diameter of the body of first sacral vertebra did not differ significantly between male and female (p=0.598).

The mean transverse diameter of the body of first sacral vertebra was 48.86 ± 6.72 mm in male and was 48.12 ± 5.03 mm in female; the transverse diameter of the body of first sacral vertebra did not differ significantly between male and female (p=0.631). Sachdeva et al[14] also found that the transverse diameter of the body of first sacral vertebra was 4.76 ± 0.71 cm in male and was 4.55 ± 0.48 cm in female; the transverse diameter of the body of first sacral vertebra did not differ significantly between male and female (p=0.380). But Maddikunta and Ravinder[15] found that the transverse diameter of the body of first sacral vertebra was 48.7 ± 6.41 mm in male and was 44.9 ± 5.72 mm in female; the transverse diameter of the body of first sacral vertebra was significantly greater in male than female (p<0.001).

The mean anterior transverse curvature of pelvic surface of sacrum at the level of S2 and S3 was 77.47 ± 6.03 mm in male and was 81.30 ± 9.60 mm in female; the mean anterior transverse curvature of pelvic surface of sacrum at the level of S2 and S3 was significantly more in female compared to male (p=0.022). This result was different from the study of Plochocki[9] that the mean anterior transverse curvature of pelvic surface of sacrum at the level of S2 and S3 was 51.9 ± 5.01 mm in male and was 51.5 ± 3.85 mm in female; the mean anterior transverse curvature of pelvic surface of sacrum at the level of S2 and S3 did not differ significantly between male and female (p>0.05).

The mean anterior transverse curvature of pelvic surface of sacrum at the level of S3 and S4 was 67.93 ± 7.12 mm in male and was 66.40 ± 6.06 mm in female; the mean anterior transverse curvature of pelvic surface of sacrum at the level of S3 and S4 did not differ significantly between male and female (p=0.373). This result was consistent with the study of Plochocki[9] that the mean anterior transverse curvature of pelvic surface of sacrum at the level of S3 and S4 was 71.1 ± 6.26 mm in male and was 71.7 ± 5.25 mm in female; the mean anterior transverse curvature of pelvic surface of sacrum at the level of S3 and S4 did not differ significantly between male and female (p>0.05).

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[17] 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). Several other studies also supported this result.[3,12,13,17]

The 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). This findings was also supported by Shreekrishna et al[12] 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 mean index of body of S1 in male and female was 60.00 ± 6.35 percent in male and was 61.81 ± 6.87 percent in female; the mean index of body of S1 did not differ significantly between male and female (p=0.293). This result was supported by Kumar and Vishwakarma[16] that the mean index of body of S1 was 57.94 ± 4.38 percent in male and was 59.53 ± 3.11 percent in female; the mean index of body of 1st sacral vertebra did not differ significantly between male and female (p=0.1518). But Shreekrishna et al[12] found that the mean index of body of S1 was 64.33 ± 6.43 percent in male and was 69.40 ± 6.9 percent in female; the mean index of body of 1st sacral vertebra was significantly lower in male compared to female (p=0.001).

The mean corporo-basal index in male and female was 47.75 ± 6.11 percent in male and was 45.29 ± 4.04 percent in female; the mean corporo-basal index did not differ significantly between male and female (p=0.070). This result was also supported by Sachdeva et al[14] that the mean index of body of S1 was 43.22 ± 4.28 percent in male and was 43.84 ± 5.44 percent in female; the mean corporo-basal index did not differ significantly between male and female (p=0.598). But Shreekrishna et al[12] found

that the mean corporo-basal index was 47.76 ± 3.93 percent in male and was 40.90 ± 4.30 percent in female; the mean corporo-basal index was significantly higher in male compared to female (p=0.001).

The mean alar index in male and female was 71.38 ± 10.72 percent in male and was 75.73 ± 9.68 percent in female; the mean alar index did not differ significantly between male and female (p=0.105). Another study found that mean alar index in male and female was 71.31 ± 12.10 percent in male and was 80.21 ± 20.97 percent in female; the mean alar index was more in female compared to male (p=0.0193).[1]

The mean auricular index in male and female was 72.65 ± 7.93 percent in male and was 67.77 ± 8.73 percent in female; the mean auricular index significantly more in male compared to female (p=0.027). Another study found that mean auricular index in male and female was 55.82 ± 8.71 percent in male and was 52.77 ± 8.31 percent in female; the mean auricular index did not differ significantly between male and female (p=0.1141).[1]

Conclusion

In conclusion, length of sacrum, curvature index and auricular index are greater in male; but the breadth of sacrum, anterior transverse curvature of pelvic surface of sacrum at the level of S2 and S3 and sacral index was greater in female; whereas differences other morphometric parameters are not significant.

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