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Original Research Article.

Morphometry of Sacrum is a Reliable Tool For Assessment of Sexual Dimorphism: An Osteological Analysis

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ABSTRACT

Background: The sacrum is a large triangular bone formed by the fusion of 5 vertebrae and forms the postero-superior wall of the pelvic cavity, wedged between the 2 innominate bones. Its blunt caudal apex articulates with the tailbone i.e coccycx and its broad upper base with the L5 at the lumbosacral angle. Since the last decade of the 19th century, various researchers have attempted to test sexual dimorphism in the sacrum. Sacrum has been studied morphologically as well as morphometrically to prove that it is a reliable tool for sexual dimorphism.

Aims & Objectives: The present study was conducted to investigate certain parameters of the sacrum that will help identify the sex of the sacrum. Also, to identify the most significant parameter for sexual dimorphism.

Materials and Methods: The present study was a cross-sectional study conducted on 110 dry sacra, obtained from the Department of Anatomy of Motilal Nehru Medical College. Allahabad, King George, Medical University Lucknow, and Ganesh Shankar Vidhyarthi Medical College, Kanpur. Vernier Digital caliper with an accuracy of 0.01 mm and digital camera were the main instruments used during the study. The parameters studied were Maximum length of the sacrum, Maximum width of the sacrum & sacral index.

Results & Conclusion: The sacrum was composed of five segments in 110 (100%) cases. The right ventral length was found to be highly significant with a p-value <0.001. The maximum width was found to be insignificant with a p-value <0.969. The sacral index was found to be highly significant with a p-value <0.001. Among all the parameters studied, the sacral index turns out to be the most reliable parameter that can be used for sexual dimorphism.

Key words: Sexual, Dimorphism, Sacral Index, Morphometry.

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INTRODUCTION

The bones of the body are the last to perish after death beside tooth enamel. Hence, by establishing personal identity with regard to gender age and stature, the determination of the sex of skeletal material is of concern to anatomists, anthropologists, paleoanthropologists, paleodemographers and forensic pathologists.[1] Krogman (1962) estimated that the precision of sex identification based on the study of the complete skeleton was 100% and of the skull with pelvis 98% of the pelvis alone 95% of the skull alone 90% and 80% long bones alone.[2]

In the mid-18th century AD, various studies indicated that sexual dimorphism is generally available in the bones of the skull, pelvis, and other bones. However, in the past, osteological studies related to sex determination were largely based on non-metric methods by detecting the presence or absence of certain characteristics observed to be more common in the particular sex (visual, inspection). It is stated that "almost all elements of the human skeleton exhibit some degree of sexual dimorphism, but results can be obtained from a few bones of which sacrum is the rare one". The sacrum is a large triangular bone formed by the fusion of five sacral vertebrae in adults. The sacrum has a base, apex, dorsal and lateral pelvic surfaces, and a sacral canal.[3] Sacrum is the Latin word derived from the word "sacer" which means "holy" or "consecrated" Greek called Heiron, Ostoum again meaning "the sacred, the bone" (Haubrich 1984). The sacrum is considered to be a eccenteric bone in the human body because it is not a single bone but a group of five sacral vertebrae that merge after puberty. The curvature of this bone is related to procreation in women and flatness, weight bearing in both sexes, the sacral promontory is the nodal point of pelvimetry, and the pelvic edge is incomplete without a sacrum.[4] So far, various researchers have cited that the skull and pelvis are of great help in determining the sex of skeletal material. However, it is observed that there is not

much work on the bony "sacrum". Therefore, the present work is an attempt to establish some of the parameters that will be of great help in the identification of sex in both forensic and anthropometric study.

MATERIALS & METHODS

The present study was cross sectional study conducted on 110 dry sacra obtained from Department of Anatomy, Motilal Nehru Medical College Allahabad, King George Medical University Lucknow and Ganesh Shankar Vidhyarthi Medical College Kanpur. Sacra which are not ossified having deformity & mutilated were excluded from the study. Instruments used during the study were Digital vernier caliper of 0.01mm accuracy & Digital camera.

Different parameters were studied under the following headings:

1. Sacral Ventral Straight Length*:* Maximum straight length was measured in millimeters up to the second decimal with the help of vernier caliper along the ventral mid-line of the sacrum from the middle of the antero-superior margin of promontry to the middle of antero-inferior margin of the last sacral vertebra (Fig:1)

2. Maximum Sacral Width: The maximum distance was noted in millimeters with the caliper by taking two points between the lateral most part of left and right ala of sacrum. (Fig: 2)

3. Sacral Index: Sacral index was then calculated by using the formula

$$\text{Sacral index} = \frac{\text{Sacral width}}{\text{Sacral ventral straight length}} \times 100$$

Fig 1: Measurement of sacral length

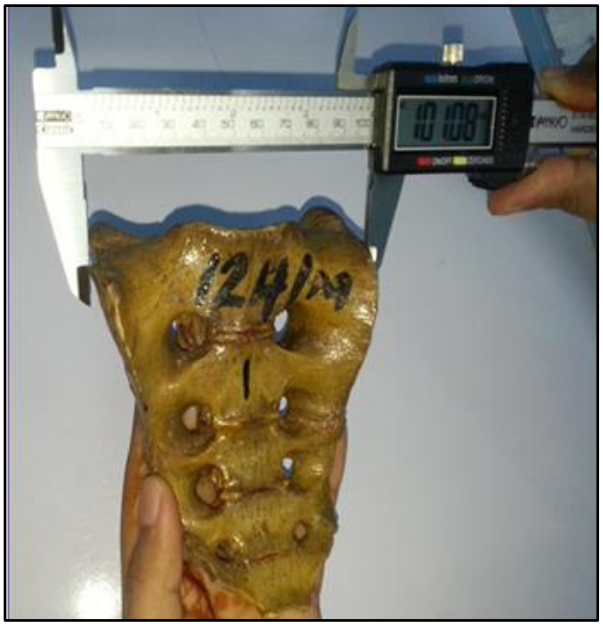

Fig 2: Measurement of maximum sacral width

Table 1: Measurement of ventral sacral height, maximum sacral width & sacral index

	Ventral sacral height		Sacral width		Sacral Index	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
No. of bones	96	42	96	42	96	42
Mean	106.40	86.72	104.37	104.28	98.35	120.88
Standard deviation (S.D.)	9.02	10.53	8.49	9.42	6.75	7.04
Calculated bone range	79.34 – 133.46	55.07-118.31	79.17-129.84	76.02-132.54	73.1- 113.6	99.76-142
Demarking points	>118.31	<79.34	>132.54	<79.17	>142	<73.1
t –value	7.46		0.04		11.61	
p- value	< 0.001 (HS)		0.969 (NS)		< 0.001 (HS)	

OBSERVATIONS & RESULTS

All the 110 sacra of unknown sex & age from north Indian population were selected observed for composition and measured for sacral ventral straight length maximum sacral width & sacral index. (Table 1)

Sacral Composition

The sacrum was made up of five segments in 110 (100%) cases.

The Ventral Straight Length:

The ventral straight length was found to be having a mean of 106.40 mm in males and 86.72 mm in females. The demarking points for males was >118.31 in males and < 79.34 in females, Ventral, straight length was found to be highly significant with a p value of < 0.001. (Table 1)

The Maximum Breadth: The maximum breadth was found to be having a mean of 104.37 mm in, males and 104.28 mm in females. The demarking point was >132.54.21 in males and <79.17 in females. Maximum breadth was found to be not significant with a p- value of <0.969. (Table 1)

Sacral Index: The mean scores between two genders was compared. Student's t test revealed, significantly different and higher sacral index score in females as compared to males (98.35±6.75 vs. 120.88±7.04). This parameter was helpful in identification of 87.3 % of bones in males and 12.7% of bones in females. Sacral index was found to be highly significant with a p-value of <0.001. (Table 1)

Table 2: Comparison of ventral straight length of sacrum with previous studies

S. No.		Males			Females			
	Investigators	**N**	**X**	**S.D**	**N**	**X**	**S.D**	**p- value**
1	**Arora et al (2010)**	20	109.74	11.66	20	91.22	6.348	<0.0001
2	**Shailaja et al (2011)**	190	11	0.84	64	9.45	0.85	<0.001
3	**Sachdeva (2011)**	40	10.41	1.26	10	9.18	0.71	<0.005
4	**Mazumdar et al (2012)**	127	100.8	11.5	123	87.3	7.4	<0.001
5	**Anant et.al (2017)**	25	104.73	5.94	25	92.64	6.1	<0.0001
6.	**Present study**	96	106.40	9.02	42	86.72	10.53	<0.001

N= Sample size, X= Mean, S.D. = Standard deviation, p= Probability

Table 3: Comparison of Maximum Width of sacrum with previous studies

S. No.		Males			Females			
	Investigators	**N**	**X**	**S.D**	**N**	**X**	**S.D**	**p- value**
1	**Arora et al (2010)**	20	101.94	8.96	20	114.13	9.67	< 0.0002
2	**Shailaja et al (2011)**	190	101.94	0.9	64	10.6	0.691	N.S
3	**Sachdeva (2011)**	40	10.31	0.78	10	10.17	0.7	N.S
4	**Mazumdar et al (2012)**	127	96.3	7.4	123	95.6	5.7	N.S
5	**Anant et.al (2017)**	25	102.93	4.83	25	104.77	6.48	N.S
6.	**Present study**	96	104.37	8.49	42	104.28	9.42	0.04

Table 4: Comparison of sacral Index with previous studies

S. No.		Males			Females			
	Investigators	**N**	**X**	**S.D**	**N**	**X**	**S.D**	**p- value**
1	**Arora et al (2010)**	20	93.24	11.57	20	125.35	11.47	< 0.0001
2	**Shailaja et al (2011)**	190	94.24	11.78	64	113.19	10.26	< 0.0001
3	**Sachdeva (2011)**	40	100.24	12.54	10	111.14	14.6	<0.016
4	**Mazumdar et al (2012)**	127	94.9	4.8	123	109.8	7.3	< 0.0001
5	**Anant et.al (2017)**	25	98.44	4.69	25	113.23	5.61	< 0.0001
6.	**Present study**	96	98.35	6.75	42	120.88	7.04	< 0.001

DISCUSSION

There have been numerous studies related to the reliability of sex estimation through quantitative assessments of sexual dimorphic features of the sacrum.[5] Research suggests that the sacrum not only exhibits sexually dimorphic patterns, but that the precision of sex estimation differs for each gender, with this precision also being influenced by the morphological variation associated with group affiliation.[6] In order for the pelvic inlet of females to be enlarged for accommodation of child bearing, it has been proposed that female sacrum have a lesser degree of sacral curvature which would be useful in estimating sex.[7]

The mean value of the right ventral length was 1046.40 mm in males and 86.72 mm in females and was statistically highly significant. This study can be compared to the previous study like Arora et.al (2010), Shailaja et.al 2011 & Mazumdar et.al 2012 where the sacral length is highly significant for estimating sex using the sacrum.[8-10] (Table 2)

The maximum width of the sacrum in men is 104.37 ± 8.49 and in women is 104.28 ± 9.4, as measured in our study with the p-value of 0.969. The result is not significant. When we compare this parameter with our studies, we find results similar to those of the studies conducted by Mazumdar et al (2012) & Anant, et.al (2017)[10,11] (Table 3). The reliability of maximum sacred width as a sexual dimorphism is somewhat controversial, with some researchers finding it to be an accurate representation of gender. While others claim that the measure is unusable in estimating sex.[12]

Sacral index was proved to be the most reliable parameter for sexual dimorphism in our study. Similar findings were reported by other workers. [8,9,10] (Table 4)

CONCLUSION

Since the sacrum is a component of the pelvic girdle with functional differences between the two sexes, it itself becomes important for gender identification in the human skeletal system. Among all the parameters studied, the sacred index turns out to be the most reliable parameter that can be used for sexual dimorphism. Continuing such studies in a defined geographic area over a period of time will certainly help to establish anthropometric standards. Such studies will also be useful in observing changing trends, if any, in metric measures that are influenced by environmental socio-economic factors, physical stress and the genetic factor.

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