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ROLE OF SACRUM IN SEX DETERMINATION IN WEST BENGAL POPULATION

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Abstract
Background: Sex classification of a bone is possible with a degree of certainty only if it can be compared to a series of bones of known sexual dimorphism. Different parameters and indices are available based on which the sex can be determined using sacrum. Thus, it always attracted the attention of the medico-legal experts for establishing the sex, because of its contribution to pelvic girdle and associated functional sex differences. Objective: Study the sexual dimorphism and regional differences of the varied features of the sacrum in West Bengal population and compare the significant anthropometric indices with similar observations across India. Material and method: The study comprised of 50 adult sacra (35 male and 15 female), obtained from the department of anatomy and department of forensic medicine of ICARE Institute of Medical Sciences and Research and Haldia Institute of Dental Sciences and Research, Haldia, West Bengal. Different parameters viz. mid ventral straight length, mid ventral curved length, ventral straight breadth, transverse diameter of base, transverse diameter of body of S_1, antero-posterior diameter of body of S_1, breadth of alae were measured and indices viz. sacral index, longitudinal curvature index and corporobasal index were calculated and statistically analyzed. Result: Sacral index was found to be the most useful criterion for identification of sex followed by breadth of alae, corporobasal index and the ventral straight breadth. Conclusion: In the present study, out of the eleven parameters of the sacrum, seven parameters yielded statistical significance between the two sexes. Therefore, it can be concluded that sex determination of the sacrum with 100% accuracy may possible only when maximum number of parameters are taken into consideration.
Keywords: Sacrum, sexual dimorphism, sacral parameters, sacral index

Introduction

Establishment of identity of human skeletal remains is one of the most challenging aspects to anatomists, anthropologists and forensic experts. Especially giving opinion regarding sex of a single unknown specimen of bone, always remains a matter of concern for paleoanthropologists, pale demographers and forensic scientists. The sex classification of a bone is possible with a degree of certainty only when it can be compared to a series of bones of known sexual dimorphism.[1] Krogman gave the opinion that the accuracy of sex identification based on the study of complete skeleton was 100% and skull with pelvis 98%, pelvis alone 95%, skull alone 90% and long bones alone 80%.[2] Stewart (1952) rightly highlighted about overlapping ranges of variation of male and female bones on the basis of development of sexual features.[3] Hooton also commented about the vastness of overlapping of sexual character of male and female skeletons belonging to different races.[4] Davivongs (1963) highlighted that as a general rule male bones are more massive and heavier than female ones. Especially additional sex differences characters of pelvic girdle occurred due to different reproductive functions mainly influenced by sex hormones.[5] Sexual dimorphic characters can be studied both morphologically and metrically. But geometric morphometrics provides more accuracy. Regarding establishment of personal individuality from adult human skeletal remains, the pelvis provides the best marked and reliable characteristics for distinguishing sex.[6]Among the pelvic girdle bones sacrum has always drawn the attention of medicolegal experts for establishing the sex due to its contribution to sex differences criteria, mainly augmented due to reproductive functions. India is a country of intermixing of races; it's often very difficult to get pure ethnic groups for study purpose. Though Chand [7](1995) has been proposed in his research paper that India may be divided into four regions like north, south, west, and east for different study purpose on local population. Different studies on the sacral anthropometry are available from different regions of the country, but hardly any population specific data from the eastern zone, except that by Jana (1988)[8], Singh and Gangrade [9] in the Burdwan region of West Bengal and Majumdar S [6]on population of Kolkata district of West Bengal, which showed significant difference in anthropometric mean value in sacrum bone in their study. Thus, the present study was conducted on the sacra of population of West Bengal to find out any regional differences, so that findings with similar observations across India may be compared with.

Material and Method:

35 male and 15 female adult human sacra were procured from the department of anatomy and department of forensic medicine under the ICARE medical college, dental college in Haldia, West Bengal and studied for anthropometric measurements and sexual dimorphism. All the selected sacra were normal, fully mature and ossified, and devoid of any fractures or pathological changes. The bones were boiled and cleaned. The methods of measurements, calculation of indices and statistical methods applied were same as used by Sachdeba [1].The measurements included length, width, curved length, antero-posterior and transverse diameter of the first sacral vertebrae, breadth of alae, sacral index, curvature index and corporo-basal index (Figure 1, Table 1 and Table 2).The metrical data was recorded from each sacrum according to the method demonstrated in Wilder's manual of Anthropometry [10]. The linear measurements were taken with the help of sliding vernier calipers and the curved distance was recorded with the help of standardized flexible ribbon tape (Figure 2, 3 and 4). Four indices were calculated for the sacra by using formula, given in the Table 2. The parameters obtained from this measurement of sacrum in the present study are given in Table 3. Collected data was tabulated and statistically analyzed using maximum and minimum values, range, mean, standard deviation (SD).The mean and standard deviation were calculated for the ranges of each parameter of both the sexes. Using these values calculated range was arrived at by the formula 'Mean ± 3SD'.The existence of significant differences between the means for the two samples was analyzed by using Student's t-test.

Result:

The mean with standard deviation, estimated range (Mean ± 3S.D) of various anthropometric parameters of sacrum in which sex could be identified are shown in Table 3. The mid straight length, curved length, transverse and antero-posterior diameter ofS_1 vertebrae, breadth of alae curvature S1, and corporo-basal indices were significantly higher in males as compared to that of females, while the breadth was comparable in both sexes. However, the sacral index was significantly higher in females as the female sacra are shorter and wider than male sacra. The sacral index was found to be the most useful criterion for identification of sex followed by breadth of alae, corporo-basal index and the ventral straight breadth. In contrast, antero–posterior diameter body $S_{1,}$ longitudinal curvature index and S_1 index are non significant and hence the least relevant in the sexual dimorphism of sacrum.

Table 1: Different parameters of sacrum

Sr. No.	Parameter (mm)	Method	Markings as in figure 1
1	Ventral straight breadth	Straight distance across the ventral surface of first sacral vertebra between the widest margins of lateral wings	NO
2	Mid ventral straight length	The midpoint of the sacral promontory to the middle of anteroinferior border of the 5^{th} sacral vertebra	LM
3	Mid ventral curved length	Length of the curved median line drawn along ventral surface from the middle of sacral promontory to midpoint of anteroinferior border of the 5^{th} sacral vertebra	LM dotted
4	Breadth of alae	Straight distance of the ala of the sacrum from the transverse diameter of the body of sacral vertebra	PP^1 and QQ^1
5	Transverse diameter body S_1	Maximum transverse diameter of the articular surface of the body of the S_1	P^1Q^1
6	Antero posterior diameter body S_1	Anteroposterior distance from the midpoint of sacral promontory upto the midpoint on the posterior border of body of S_1	LA
7	Transverse diameter base	Maximum transverse width of the superior surface of sacrum , comprising the two alae	PQ

Table 2: Formula for different indices of sacrum

Serial number	Index	Calculated as
1	Sacral index	$= \frac{\text{Ventral straight breadth}}{\text{Sacral ventral straight length}} \times 100$
2	Corporo basal index	$= \frac{\text{Corpus width of } S_1}{\text{Breadth of base of sacrum (upper surface)}} \times 100$
3	Longitudinal curvature index	$= \frac{\text{Mid ventral straight length of sacrum}}{\text{Mid ventral curved length of sacrum}} \times 100$
4.	S_1 index	$= \frac{\text{Anteropostero diameter of } S_1}{\text{Transverse diameter of } S_1} \times 100$

Table 3: Results of Sacral parameters in the present study

Serial number	Parameter	Sex	Mean ± Standard deviation	Range	P-value
1.	Mid ventral Straight Length (mm)	M	104.8 ± 10.6	69.4 -132.4	<0.011*
		F	90.8 ± 7.0	78.2 -108.5	
2.	Mid ventral Curved Length (mm)	M	106.4 ± 7.4	95.0 - 126.3	<0.547
		F	100.0 ± 5.2	98.3 - 115.4	
3.	Ventral straight breadth (mm)	M	97.4 ± 7.2	76.3 - 112.0	<0.009*
		F	96.2 ± 5.6	80.2 - 115.6	
4.	Breadth of Alae (mm)	M	3.15 ± 0.47	2.47 - 4.50	<0.001**
		F	2.86 ± 0.38	2.2 - 4.00	
5.	Transverse diameter Body S_1 (mm)	M	42.8 ± 7.6	15.1 - 65.7	<0.021*
		F	40.3 ± 5.8	22.3 - 59.4	
6.	AP diameter Body S_1 (mm)	M	30.5 ± 4.6	16.0 - 42.8	<0.632
		F	27.4 ± 3.2	19.3 - 37.3	
7.	Transverse diameter base (mm)	M	12.08 ± 0.68	10.70 - 14.50	<0.015*
		F	11.24 ± 0.72	10.34 - 12.35	
8.	Sacral index (%)	M	99.3 ± 5.6	79.4 - 141.5	<0.001**
		F	111.2 ± 10.3	89.7 - 136.4	
9.	Longitudinal curvature index (%)	M	92.0 ± 3.6	70.0 - 100.2	<0.391
		F	89.3 ± 4.5	65.3 - 99.1	
10.	Corporobasal index (%)	M	44.9 ± 10.3	25.6 - 62.9	<0.005*
		F	42.7 ± 5.6	34.8 - 55.8	
11.	S_1 index	M	68.6 ± 8.2	40.3 - 96.9	<0.105
		F	67.2 ± 5.3	55.0 - 90.0	

Abbreviations: S_1- First Sacral Vertebra, P-value of significance by Students T-Test *- Significant, **- Highly significant

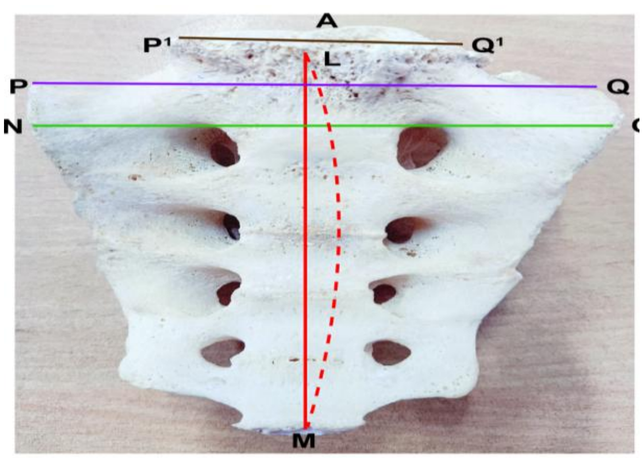

Figure 1: Measurements of different lengths and breadths of sacrum

Figure 2: Ventral straight breadth

Figure 3: Mid ventral straight length

Figure 4: Corpus width of S_1

Discussion:

The study result showed that both straight and curved lengths of the sacrum were more in males than female in West Bengal population. Similar results were found in different

population of North India by Sachdeva[1], Varanasi by Raju PB[11], Kolkata by Majumdar [6] and Agra by Mishra SR[12] but findings are different in case of Australian Aborigines.[3] Ventral straight breadth of male sacra was found to be comparable with females and the mean difference was statistically significant (p-value = 0. 009). Similar results were found by Majumdar [6] in their study population. Davivongs[5] (1963) and Mishra[12] (2003) found it to be more in females. However in the present study, male sacra were wider as compared with females by a mean of 1.2 mm. Breadth of ala was more in males in this study, the difference being statistically highly significant. Mishra[12] in Agra population found it more in females .With contrast to that, in the present study, it was more in males by 0.29 cm. Thus the ala of male sacra in Bengali population was much wider than ala of female sacra. Study results showed that the transverse diameter of body of S_1 is more in males of the present study than female as compared to the other races, resulting comparatively narrower alae in the females of Bengali population. Sachdeva [1]in their study showed that transverse diameter of body of S_1 of male and female sacra were more or less comparable in north Indian population. Transverse diameter of base of sacrum was more in males than female in present study, similar to both in Varanasi [11] and in North Indian population [1].The mean sex difference of transverse diameter of base in our study was statistically significant (p-value < 0.015). In present study average value for sacral index in males was 99.3 ± 5.6 and that for females was 111.2 ± 10.3.Mean value of female was significantly higher than male. The mean value of Sacral index for male sacra (99.3) in this study was higher than that of Kolkata region (94.9) studied by Mazumdar [6], Amritsar region (93.69) studied by Arora[13], Gulbarga region (94.24) studied by Math[14], Singh (94.32) [9]and Jana [8] (91.27) in Burdwan region. It was lesser than that of Amritsar region (100.24) studied by Sachdeva[1], Shreekrishna HK [15] in Tamilnadu region (99.21), Varanasi region (100.85) studied by Raju [11], Flander (106.49)[16]in black population, Davivongs (104.16)[5] but similar results to that findings of Patel[2] in Jamnagar region (96.25) and Agra region (98.21) studied by Mishra [12]. The mean value of Sacral index for female sacra (111.2) in present study was higher than that of Kolkata region (109.8) studied by Mazumdar[6], Amritsar region (111.74) studied by Sachdeva [1], Singh[9](104.81), Jana[8](103.89) [14], Varanasi region (111.39) studied by Raju [11]and Flander [16](108.69).It was lesser than that of Shreekrishna [15] in Tamilnadu (119.94), Amritsar region (125.35) studied by Arora [13], Agra region (117.84) studied by Mishra[12], Davivongs [5] (115.49) ,Gulbarga region (113.19) studied by Math[14], Patel[2] Jamnagar (113.25), but similar to the study results of Flander [16] in black population (112.35). The mean difference of sacral index in the present study was highly statistically significant. The longitudinal curvature index was found more in males as compared to females in this population group, which corroborated the findings of Davivongs [5](1963). Next index calculated in the presentstudy i.e. corporobasal index was more in males as compared to the females, which is contrast to the study findings by Sachdeva in North Indian population. This index was statistically significant more in case of male sacrum. The fourth index that has been studied was S_1index is more or less comparable for both male and female sacra, but the mean difference of this index in the present study was statistically insignificant.

Summary and conclusion:

Sacrum, being an integral component of pelvic girdle with functional differences among two sexes becomes an important tool for identification of sex in the human skeletal system. The maximum differences between the male and female sacra were observed in the measurements of mid ventral straight length followed by mid ventral curved length of the sacrum. Amongst the indices, the sacral index was the best parameter for identification of sex of sacrum followed by corporo-basal index. Though, not a single parameter could identify sex in 100% of the bones, accuracy increases when maximum number of parameters is being considered for sex determination. Thus continuance of such studies in a defined geographic area over a period of time will definitely help in establishing the anthropometric standards. Observation of these study results for any changing trends in the metric measurements, which may be due to influence of environmental, socioeconomic, physical or genetic factors; may have immense importance in forensic medicine, anatomy and anthropology.

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