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Research Article

Various sacral indices: role in study of sexual dimorphism

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ABSTRACT

Background: Skeleton is an excellent material in living and non-living population for genetic, anthropological and forensic investigations. Sound anatomical knowledge of human osteology in the evaluation of death may help to shed light on legal issues such as sex and age determination, parentage and racial identity. It has widely recognized that skeletal characters vary among different racial groups and even within the same racial groups. Sacrum is one of the commonest part of skeleton used to opine the sex. The study documents effort to determine sex by using different measurements of the sacrum and calculating the different indices based on these measurements. The most useful aspect of such study is to evaluate the role of different indices of sacrum in sex determination.
Methods: Study was carried out on 141 adult, dry sacra in Department of Anatomy, BVDU Medical College, Pune. 141 sacra were classified into male and female bones by observing the parameters like - length of sacrum, width of sacrum, transverse diameter of body of S1, anteroposterior diameter of S1, length of ala of sacrum.
Results: The indices like sacral index, curvature index, corpobasal index and alar Index were found to be statistically significant with p value <0.001/ <0.05. The index of body of S1 had p value >0.05 and was statistically not significant.
Conclusions: The most useful aspect of such studies was to determine appropriate indices of sexual dimorphism for sacral bone. The study concluded that no single index can identify sex of sacrum with 100% accuracy. So multiple indices should be used for determination of sex by sacrum with 100% accuracy.

Keywords: Sacrum, Parameters, Indices, Sexual dimorphism

INTRODUCTION

The ultimate aim of using anthropometry in forensic medicine/science is to help to find out 'personal identity' in case of unknown human remains. Almost all elements of human skeleton show some degree of sexual dimorphism. There are no fixed criteria regarding which variables of which bone should be chosen in order to assess its sex. Absolute sexual differences seldom exist.[1] Taylor, in his medical jurisprudence has postulated the accuracy of sexing by using various bones and with the help of statistical analysis.[2] Hamilton M. stated that intensity of skeleton is greater in females because of the requirement of reproduction and lactation. The growth and development in females is more canalized.[3,4]

This sex difference can be the result of genetic factors, environmental factors affecting growth and development (nutrition, physical activity, and pathologies), or the interaction of these factors.[5] Due to the regional variability identification standards cannot be applied

across population, which call for group specific standards, to optimize the accuracy of identification.

In general the female bones are usually smaller and of less diameter in shaft relative to length than male bones. Pelvis remains the most reliable region for assessing sex. Sacrum, as a part of pelvis also demonstrates differences.[6] Sacrum is an ideal bone for determination of sex because it not only reflects general differences between the two sexes but shows special adaptations in females for child bearing. Thus the present study is an attempt to test the applicability of various indices of sacrum for sex assessment and to investigate which variable of sacrum is more useful in the metric diagnosis of sex.

Aim

To find out the role of different indices of sacrum and to estimate reliable and accurate indices for sex determination of sacrum in adults.

METHODS

Study was carried out in Department of Anatomy, BVDU Medical College, Pune. 141 adult, dry sacra were collected randomly from Anatomy department of different Medical colleges of Maharashtra, with the kind permission of the concerned authorities. 141 sacra were classified into male and female bones by observing the parameters like - length of sacrum, width of sacrum, transverse diameter of body of S1, anteroposterior diameter of S1, length of ala of sacrum.

In order to avoid observer's error, all the parameters were measured and recorded single handedly. For each of the parameters, three readings were taken and then their mean was taken as final reading. The method of measuring sacra was practiced on available bones in the department, to ensure the elimination of recording error. The practice was continued till three successive readings of the measurements were similar.

Various indices were calculated as follows:-

Sacral index = (Maximum width of sacrum / Straight length) X 100

Curvature index = (Maximum width of sacrum / Midventral curved length) X 100

Index of body of S1 vertebra = (Anteroposterior diameter of body of S1/Transverse diameter of body of S1) X 100

Corpobasal Index = (Transverse diameter of body of S1/ Width of sacrum) X 100

Alar Index = (Mean length of ala / Transverse diameter of body of S1) X 100

Auricular Index = Length of auricular surface (Mean) / Width of sacrum X 100

After completing measurements, the data was tabulated; indices were calculated and analyzed for range, mean, standard deviation etc. Comparison of each of index was done by applying -'Z' test and obtaining 'p' value and calculation of demarking point (DP).

Using these values 'calculated range' was arrived at by the formula 'meant ± 3SD'. The mean ± 3 SD gave the range that covered 99.75% of population of that area. For a given male calculated range of 'p to q' and female calculated 'r to s', values of 'p' (minimum in male range) and's' (maximum in female range) were chosen as 'demarking points' (referred to as DP hereafter) for females and males respectively.[7] Sacra with measurement less than 'p' were identified as female sacra and greater than's' as male sacra for curvature index and corpobasal index. Whereas sacra with measurement lesser than 'r' were identified as male sacra and greater than 'q' as female sacra for sacral index, index of body of S1 and alar index.

RESULTS

The indices like sacral index, curvature index, corpobasal index and alar index were found to be statistically significant with 'p'value <0.001/ <0.05. The index of body of S1 had 'p' value >0.05 and was statistically not significant. Thus among the above indices, all were dimorphic except Index of body of S1. It is probably due to the fact that the relatively wider sacra expected in females are being "obscured" by the larger body sizes of male sacra.

The % of bones identified beyond DP was maximum with sacral index. 12.5% as male and 18.84% as female could be identified. Curvature index and index of body of S1 vertebra in male sacra appeared to be ineffective indices as no bone could be identified beyond DP. With the help of DP for each index, very few sacra could be sexed correctly. It was because of a lot of overlap in the values for male and female sacra.

Considering all the indices, 16.67% as male sacra and 30.53% as female sacra could be identified. Thus by calculating DP in 47.20% of the sacra, sex could be ascertained with almost 100% accuracy.

Figure 1: Ventral straight length.

Table 1: Range, mean value, DP & % of bones identified beyond DP.

Index	Sex	Range (mm)	Mean=/- 3SD	D.P.	% of bones
Sacral index	M	76.55-125.39	63.89-125.39 mm	< 86.94	12.5%
	F	88.04-153.43	86.94-148.22 mm	>125.3	18.84%
Curvature index	M	70.60-102.33	77.93-103.87 mm	>106.4	0%
	F	71.50-100.3	71.86-106.42 mm	<77.93	2.90%
Index of body of S1 vertebra	M	51.38-78.30	48.75-78.41 mm	<41.47	0%
	F	35.30-88.43	41.47-89.17 mm	>78.41	2.89%
Corpobasal index	M	35.40-54.56	32.35-53.98 mm	>50.41	2.78%
	F	31.80-49.15	27.98-50.41 mm	<32.35	1.45%
Alar index	M	43.61-90.44	40.38-97.97 mm	<45.88	1.39%
	F	50.48-105.4	45.88-112.99 mm	>97.97	4.35%
Auricular index	M	45.30- 67.2	41.51 – 71.43 mm	>66.92	1.39%
	F	38.29-66.9	35.28 – 66.92 mm	<41.51	5.80%

Table 2: Statistical analysis of various indices.

Index	Sex	Mean	SD	z value	p value	Significance
Sacral index	M	102.31 mm	7.69	9.99	<0.001	Highly significant
	F	117.58 mm	10.21			
Curvature index	M	90.89 mm	4.32	2.05	<0.05	Significant
	F	89.14 mm	5.76			
Index of body of S1 vertebra	M	63.58 mm	4.94	1.53	>0.05	Not significant
	F	65.29 mm	7.94			
Corpobasal index	M	43.17 mm	3.60	6.41	<0.001	Highly significant
	F	39.19 mm	3.74			
Alar index	M	69.18 mm	9.59	5.83	<0.0001	Highly significant
	F	79.44 mm	11.18			
Auricular index	M	56.48 mm	4.99	6.21	<0.0001	Highly significant
	F	51.50 mm	5.27			

Table 3: Comparison of sacral and curvature index with other studies.

Investigator	Sacral index				Curvature index		
	Sex	Mean	SD	P value	Mean	SD	P value
Davinvongs	M	104.16	--	<0.001	92.54	3.74	<0.05
	F	114.49	--		90.80	4.20	
S.R.Mishra	M	98.21	4.89	<0.001	95.22	1.99	<0.001
	F	117.84	7		90.72	3.46	
Raju et al	M	100.85	8.70	<0.001	92.77	3.88	<0.01
	F	111.39	7.67		88.51	3.99	
Renuka	M	97.94	2.60	<0.001	92.36	5.50	<0.001
	F	113.18	9.73		83.47	4.93	
Present study	M	102.31	7.69	<0.001	90.89	4.32	<0.001
	F	117.58	10.21		89.14	5.76	

Table 4: Comparison of index of body of S1 and corpobasal index with other studies.

Investigator	Index of body of S1 vertebra				Corpobasal Index		
	Sex	Mean	SD	P value	Mean	SD	P value
Davinvongs	M	63.30	4.4	NS	47.42	3.24	<0.001
	F	62.84	6.25		43.62	3.66	
Mishra S.R.	M	61.73	4.07	<0.05	46.54	3.17	<0.001
	F	68.16	4.92		40.47	3.37	
Raju P.B. et al	M	64.42	7.4	NS	44.92	4.64	<0.01
	F	65.52	6.27		40.96	3.18	
Renuka	M	63.61	7.60	<0.001	44.57	4.0	<0.001
	F	66.37	7.15		41.41	3.76	
Present study	M	63.58	4.94	NS	43.17	3.60	<0.001
	F	65.29	7.94		39.19	3.74	

Table 5: Comparison of alar and auricular index with other studies.

Investigator	Alar index				Auricular index		
	Sex	Mean	SD	P value	Mean	SD	P value
Mishra S.R.	M	56.10	7.34	<0.001	59.78	4.06	<0.001
	F	72.60	8.42		51.69	3.69	
Raju P.B. et al	M	62	11.79	<0.01	--	--	--
	F	72.40	8.74		--	--	
Renuka	M	64.22	9.9	<0.001	52.07	4.30	<0.001
	F	72.29	11.21		45.18	3.82	
Present study	M	69.22	9.59	<0.001	56.48	4.99	<0.001
	F	80.94	11.18		51.50	5.27	

Figure 2: Maximum width (breadth) of sacrum.

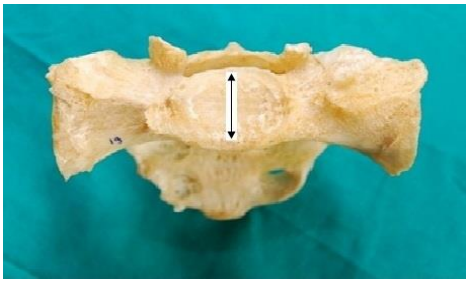

Figure 3: Anteroposterior diameter of body of S1 vertebra.

Figure 4: Transverse diameter of body of S1 vertebra.

Figure 5: Length of ala of sacrum.

DISCUSSION

Anthropometric characteristics have direct relationship with sex, shape and form of an individual and these factors are intimately linked with each other and are manifestation of the internal structure and tissue components which in turn, are influenced by environmental and genetic factors8. Sacrum is one of the commonest part of skeleton used to opine the sex. Extensive studies on metrical analysis were done by workers. On the basis of literature sited on observed sex differences in sacrum two hypotheses are proposed, univariate and multivariate analysis.[9-11] In univariate analysis, observed sex differences like size, curvature, number of sacral vertebrae, extent of auricular surface, ala and first sacral vertebra have found valid criteria to determine sex by sacrum. These parameters were evaluated by student's 't' test and obtaining 'p' value (<0.01 or >0.05). Results for the samples (males and females) are then compared. In this method phenomenon of overlapping was mentioned.

In univariate method of analysis, if the sexing is done on the basis of demarking point (DP), calculated for each parameter the chances of wrong diagnosis of sex are negligible. The demarking points of various parameters if crossed by any sacrum will identify the sex with certainty which is important in medico legal cases. However it is not necessary for any bone to cross the DP of all the parameters. Any single DP for any of the parameters, if crossed would detect the sex with 100 % accuracy.[7] It has been worked out that it is necessary to determine the DP separately for each race and even for different regions of a same population.[12]

In general the mean of Sacral Index was higher in females than males. The values for male sacra were closer to study by Davinvongs[13] whereas values for female sacra were closer to study by S.R. Mishra.[14]

The male sacra are more evenly curved and relatively long and narrow, accounting for larger curvature index in male sacra.[6] In the present study, the mean of Curvature Index for male sacra was more than female sacra and findings were similar to previous studies.

In the present study, Index of body of S1 was statistically not significant and findings were comparable with Raju P.B. et al[12] and Davinvongs[13] and Renuka.[15]

The Alar index in males as well females of present study was more than previous studies. The values for Auricular index were more comparable with study by Mishra S.R.[14]

The bones which could be identified by DP were few in number, but identification of bones with 100% accuracy is needed in medico legal cases.

CONCLUSION

Sacral index was most reliable index as 31.34% of sacra could be identified beyond D.P. (12.4% male & 18.5% female) with almost 100% accuracy.

Considering all the indices, 16.67% of male sacra and 30.53% of female sacra could be identified. Thus by calculating DP, 47.20% of the sacra could be ascertained sex with almost 100% accuracy.

All the indices except index of body of S1 were statistically significant in the present study and also in the findings of other research workers. So these parameters can be used for identification of sacrum in medico legal cases. It will also help to determine appropriate standards of sexual dimorphism in different populations.

Demarking points of all the parameters could identify the sex of only few sacra leaving a large number of sacra in unidentified zone. It can be concluded that to identify the sex of sacrum with 100% accuracy single parameter is not sufficient instead it requires multiple parameters and indices to reach at the most accurate result.

Thus for different populations based on geographic areas different anthropometric criteria should be applied which could be specific to that particular population.

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