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Original Research Article

AN ANATOMICAL STUDY OF ADULT SACRUM WITH ITS EMPHASIS ON ITS SEXUAL DIMORPHISM IN SOUTH INDIAN POPULATION

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ABSTRACT

Aim: To study the various morphometric parameters of the dry sacra of unknown sex in South Indian population in detail and to determine their demarcating points in order to increase the efficiency of sexing in the given population.

Methods: 87 dry adult human sacrum of known sex (42 males and 45 females), belonging to South Indian (Karnataka) region were obtained. Various parameters like Length (L), breadths (B), Transverse diameter of the body of the 1st sacral vertebrae (TS1) & Curved Length of Sacrum (CL) were obtained. From these parameters, Sacral Index (SI), Curvature Index (CI) and Corporo-basal Index (CBI) were calculated & from the obtained values demarking points (D.P) were calculated. The values were stastically analyzed.

Results: Among these parameters, the values for the Length (L), Curved Length (CL) and Sacral Index (SI) were stastically significant

Conclusion: Length (L), Curved Length (CL) and Sacral Index (SI) were useful parameters and by obtaining their demarking points, it helps in sexing the sacrum with greater accuracy.

KEY WORDS: Sacrum, Sexing, Morphometry, Sacral Index, Karnataka.

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INTRODUCTION

The identification of sex of the human skeletal remains an important component of many anthropological investigations, and should be based on measurements and observations on the entire skeleton to be meaningful [1]. For the identification and sexing of the individual, bony elements have contributed a lot in the past for anthologists, anthropologists, forensic experts etc. Various skeletal elements like Skull, pelvis etc have been used in varied region and ethnical origin and studied in detail with good and reliable accuracy in predicting the sexing of the individual [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]. Although sacrum is a very important bone of medico legal importance, bony metric analysis of the sacrum in our ethnic group and race are scarce in the literature. It has been noted that Sacral Index, is the single most important parameter in various parameters of the sacrum, in assessing the sexual dimorphism of the given population [4, 5].

So our main emphasis was to note the various parameters of the bony sacrum in the both sexes in our south Indians in Karnataka sub populations, with an emphasis on its Sacral Index & the calculation of the Demarcating Point (DP) for the parameters, which will be useful in sex identification in our regions.

MATERIALS AND METHODS

The materials for the present study included 87 dry adult human sacrum of known sex (42 males and 45 females) and of South Indian origin (Karnataka) obtained from Bone bank of the Department of Anatomy, Srinivas institute of medical Sciences & Research Center, Mangalore, Karnataka state and Kasturba Medical College, Mangalore & Manipal, Manipal University, Karnataka state, India. These sacra were selected after rejecting the bones having any pathological or developmental anomalies etc.

The antero-posterior diameter or Length (L) and perpendicular to this, transverse diameter or breadths (B) of the male and female sacrum were measured separately using sliding vernier calipers based on standard guidelines (Fig. 1) [6]. In addition to this, Transverse diameter of the body of the 1st sacral vertebrae (TS1) using sliding vernier calipers and Curved Length of Sacrum (CL) using the flexible steel tape are also obtained. From using these above measurements the Sacral Index (SI), Curvature Index (CI) and Corporo-basal Index (CBI) were calculated using the formulas [7]:

1. Sacral Index (SI) = L / B x 100
2. Curvature Index (CI) = L / CL x100
3. Corporo-basal Index (CBI) = TS1 / B x100

Data analysis of the obtained values was analyzed statistically using SPSS software version11.5 for windows. The mean and standard deviation (SD) of each dimension were computed and compared using the Student's t-test. A probability (p) of less than 0.05 was considered statistically significant. Also from the obtained values demarking points (D.P) were calculated and the percentage of the bones thus identified, were found out in relation to each parameter [8].

Fig 1: Photograph showing the measurement of Breadth (B) & Length (L) of the Sacrum.

RESULTS AND OBSERVATIONS

From the obtained mean values of different parameters, we can observe that the mean value for Length, Breadth, and curved length is higher in male sacra (Fig. 2) and in that of indices, sacral index and Curvature index are more in case of female sacra (Fig. 3).

Fig. 2: Bar diagram showing the Length (L), Breadth (B) & Curvature Length (CL) in Male & Female Sacrum

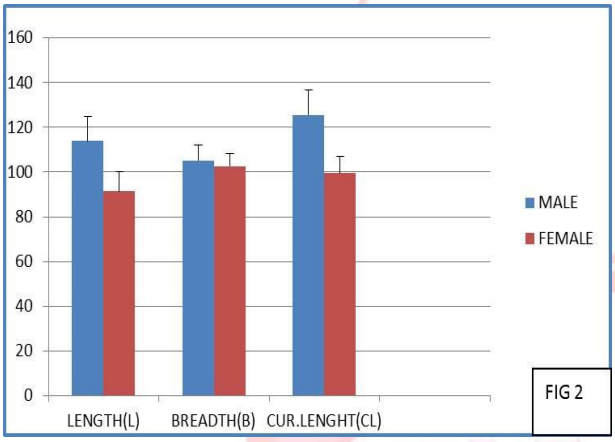
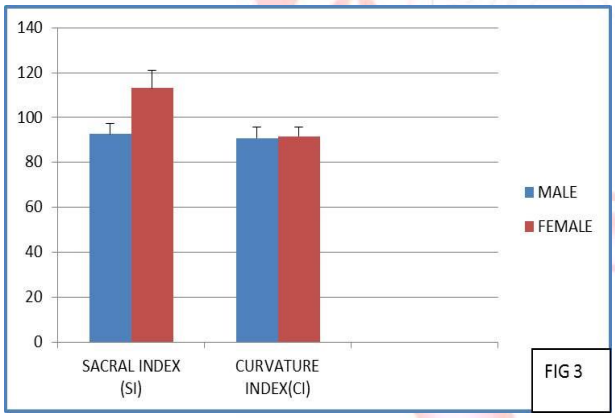


Fig. 3: Bar diagram showing the Sacral Index (SI) & Curvature Index (CI) in Male & Female Sacrum



In this study the Mean value, Standard deviation (SD) , Range, Calculated Bone Range (CBR), 'P' value for statistical significance, Demarking point (DP) and the percentage (%) of bones thus identified with the help of demarking point for different parameters, for both the sex were analyzed and tabulated (Table 1).

The sex determination of these bones was done using different measurements and indices. To be more precise, calculated bone range (CBR) was obtained by the formula: (CBR = Mean ± 3 x SD), where SD stands for Standard Deviation. The limiting point of such calculated range is called a 'demarking point' (DP), which identifies sex from the corresponding region [9]. The demarcating points of such parameters were used for the identification of the sex of the given sacrum [10].

We observed that difference of the mean in both the sexes for Length of sacrum (L), Curved Length of sacrum (CL) & Sacral Index (SI) were statistically significant (P<0.001) (Table 1).The percentage of bones we could determine by obtaining the DP of these parameters were, 42.8 % & 14.8% in cases of males (M) & females (FM) for Length of sacrum (L), 66.6 % & 20% in cases of males (M) & females (FM) for Curved Length of sacrum (CL) and 16.6% & 77.7% in cases of males (M) & females (FM) for Sacral Index (SI) respectively.

he mean values of other parameters, like the Breadth (B), Transverse diameter of the body of the 1st sacral vertebrae (TS1), Curvature Index (CI) & Corporo-basal Index (CBI) were not statistically significant between the sexes (p > 0.001) (Table 1).

Table 1: Showing various sacral parameters in adult sacra of males & females.

SL.NO	PARAMETERS	SEX	No.	MEAN	SD	RANGE	PVALUE	CALCULATED BONE RANGE (CBR)	D.P	%of bone Identified
1	Length of Sacrum(L)	MALE	42	113.88	10.96	92.6 – 132.6	<0.0001	81.3 – 146.46	>117.51	42.80%
		FEMALE	45	91.29	8.74	79 – 106		65.07-117.51	< 81.3	14.80%
2	Breadth of Sacrum (B)	MALE	42	105.21	7.06	88.7 – 116.5	> 0.06	84.03 – 126.39	<86.1	0
		FEMALE	45	102.66	5.5	93.2 – 119		86.1 – 119.1	> 126.39	0
3	Curved Length of Sacrum (CL)	MALE	42	125.55	11.18	102 – 142	< 0.001	92.01 – 159.09	>122.29	66.60%
		FEMALE	45	99.46	7.61	83 -117		76.63 – 122.29	< 92.01	20%
4	Transverse diameter of the body of the 1st sacral vertebrae (TS1)	MALE	42	48.17	5.44	38.6 – 55.4	> 0.17	31.85 – 64.49	>63.86	0
		FEMALE	45	46.52	5.78	36 – 56.5		29.18 – 63.86	<31.85	0
5	Sacral Index (SI)	MALE	42	92.71	4.53	82.98 – 98.45	<0.0001	79.12 – 106.3	<88.82	16.60%
		FEMALE	45	113.06	8.08	97.16 – 131.63		88.82 – 137.3	>106.3	77.70%
6	Curvature Index (CI)	MALE	42	90.77	4.79	82.19 – 99.23	> 0.29	76.4 – 105.14	>103.62	0
		FEMALE	45	91.62	4	83.26 – 97.85		79.62 – 103.62	<76.4	0
7	Corporo-basal Index (CBI)	MALE	42	45.72	3.84	39.57 – 52.41	>0.59	34.2 – 57.2	> 58.93	0
		FEMALE	45	45.25	4.56	36.73 – 54.53		31.57 – 58.93	< 34.2	0

Table 2: A comparison of various sacral parameters in previous studies.

parameters	SEX	Singh et al, 1972 (Varanasi)	Mishra et al, 2003 (Agra)	Kannika et al, 2011 (North India)	Jyothinath et al, 2012 (Andhra Pradesh)	Maddikunta V & Ravinder, 2013 (Telangana)	Ravichandran et al, 2013 (south India)	Shailendra et al, 2014 (Madhya Pradesh)	Present Study (Mangalore)
Length of Sacrum(L)	M	104.96	107.53	104.1	98.53	113.9	97.8	109.47	113.88
	F	92.72	90.58	91.8	100.16	90	90.96	94.46	91.29
Breadth of Sacrum (B)	M	105.33	105.34	103.1	101.13	104.2	93.7	106.42	105.21
	F	103	105.79	101.7	108.13	103.4	92.91	97.61	102.66
Curved Length of Sacrum (CL)	M	112.75	119.56	113.5	112.51	125	-	-	125.55
	F	104.81	100.95	104.5	105.25	100	-	-	99.46
Transverse diameter of the body of the 1st sacral vertebrae (TS1)	M	47.33	49.12	47.6	44.62	48.7	-	-	48.17
	F	42.18	42.81	45.5	42.27	44.9	-	-	46.52
Sacral Index (SI)	M	100.85	98.21	100.24	104.08	91.8	96.32	97.61	92.71
	F	113.39	117.84	111.74	115.78	116.3	102.29	113.4	113.06
Curvature Index (CI)	M	92.77	92.46	91.59	90.56	90.8	-	-	90.77
	F	88.51	90.86	87.87	88.66	90.1	-	-	91.62
Corporo-basal Index (CBI)	M	44.94	47.42	43.42	44.15	46.6	-	-	45.72
	F	40.96	43.62	43.84	44	42.9	-	-	45.25

DISCUSSION

The review of literature showed that not many studies are available for South Indian sacra especially belonging to Karnataka region. So in the present study, the values of various sacral indices in both the sexes were compared with those already reported in various regions of the country (table2) and they are discussed as follows.

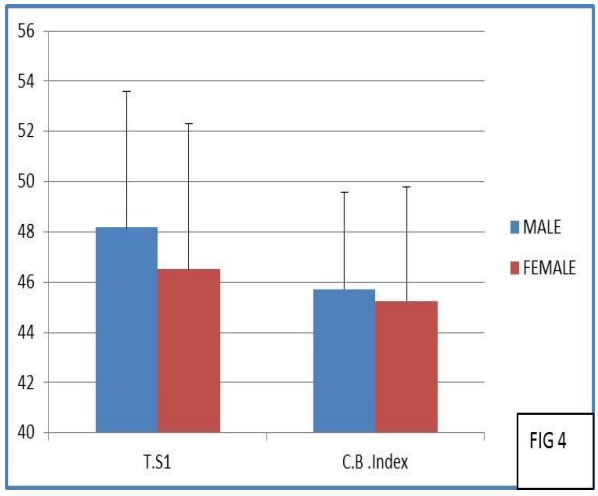
1. In the present study, the mean length (L) of the male sacra was found to be higher than that of the female sacra (Fig 2, Table 1). The Mean value for the length of the sacrum in males is 113.88 mm and that of females is 91.29 mm, which is comparable with many previous studies in various subpopulations [7, 10, 11,]. In the present study, this obtained difference is statistically significant ($p<0.0001$), as noted by other past studies [7, 12]. Similarly, the obtained values for the length of the female sacra in our study group were also comparable with previous studies; however they were less than that of Madhya Pradesh and Andhra Pradesh populations [12, 13].

2. The mean breath (B) of male sacrum were higher than that of females (Fig 2, Table 1) as noted by various authors [7, 10, 11, 12], however this difference was not stastically significant. The breadth of the female sacra in our study group was less as compared to North Indian and Andhra population [10, 13].

3. Similar to the Mean Length (L), the Curved Length of Sacrum (CL) were higher in male sacra and this difference was stastically significant [Table 1]. The values in our subsets were comparable with that of values obtained in telangana region [7].

4. In present study, the values for transverse diameter of the body of the 1st sacral vertebrae (TS1) in males were higher than females, and it was not statistically significant (Fig 4,Table 1). These values were slightly more than that of North Indian and Andhra population for both the sexes [11, 13].

Fig. 4: Bar diagram showing the Transverse diameter of 1st Sacral Vertebrae (TS1) & Corporo-basal Index (CBI) in Male & Female Sacrum.



5. The mean values for curvature index (CI) of the male sacra were slightly less than that of female sacrum; however it is not statistically significant (Fig. 4 Table 1). The obtained values for male sacra is in concordance with that of telangana [7] and Andhra Pradesh regions [13] [Table 2], whereas for female sacra, it was slightly higher than other past studies [7, 10, 11, 13, 14].

6. The Corporo-basal Index (CBI) of male sacra is more than previous North Indian studies [11] however lesser than telangana region [7]. However in the present study, the difference between the two sexes were very less and not significant (Fig 4, Table 1).

7. The present value of Sacral Index (SI) in the males is 92.71(Table 1). A comparison of our results with the previous authors showed that our results are almost similar to that of telangana region by Maddikunta et al, 2014[7] (91.8) & in Punjab region as noted by Aurora et al, 2010 [15] (93.68). Also, the sacral index was less compared to that of Patel et al, 2005 [3] in Saurashtra region (96.2), Ravichandran et al, 2013 [5] in South Indian region (96.32), Mishra et al, 2003 [10] in Agra region (98.21), Kanika et al, 2011[11] in North India (100.24), Jyothinath et al, 2012[13] in Andhra region (104.84) & also by Mamatha et al, 2012 [16] (115.92). Based on the results we classify our male sacra of the Karnataka region under Dolichohierisch category (narrow sacra with SI <100).

The present value of Sacral Index (SI) in the females is 113.06 (Table 1), which is of almost similar with the previous studies as noted by Patel et al., 2005[3] in Saurashtra region (113.25), Singh et al, 1972[14] in Varanasi region (113.39) & by Shailendra et al, 2014[12] (113.4) in the Madhya Pradesh regions. However in some other studies by Mishra et al., 2003[10] (117) Arora et al., 2010 [15] (125.35), Mamatha et al., [16] (125.02), Jyothinath et al., 2012 [13] (115.7) and Maddikunta et al, 2014 [7] (116.3) have obtained slightly higher values as compared to our study population. We will classify these female sacra in our Karnataka region under platychierisch category (broad sacra with SI >106). This is in concordance with many previous authors, who also classified the female sacra under platychierisch category Patel et al, 2005 [3]; Mishra et al 2003 [10]; Kanika et al 2011 [11]; Jyothinath et al 2012 [13]; Mamatha et al, 2012 [16]; Maddikunta et al, 2014 [7].

The present value of Sacral Index (SI) in the males is 92.71 [Table 1], so we can classify these sacra in our Karnataka region under dolichohierisch category (Narrow sacra with SI < 99.9). Similar results to us is noted in many population subsets like in those of Agra population by Mishra et al, 2003[10]; in Telangana region by Maddikunta et al, 2014[7]; in Madhya Pradesh subsets by Shailendra et al, 2014 [12] and also in South Indian population comprising of Tamilnadu & Andhra Pradesh subsets as observed by Ravichandran et al, 2013[5].

This difference of the obtained values of Sacral index between the male and female sacra was found to be stastically significant ($p<0.0001$), similar to many studies done in the past Jyothinath et al 2012 [13]; Ravichandran et al, 2013 [5]; Maddikunta et al, 2014 [7]; Shailendra et al, 2014 [12].

In the present study, the Demarcating Point (DP) for the Sacral Index (SI) is <88.82 for males and > 106.3 for females (Table 1). Since the parameters of sacra various among different population subsets, it is important to calculate the DP range which increases the reliability in identification of sex of sacra. With this obtained demarcating values, we could identify 16.6% of male and 77.7% of female sacra respectively.

CONCLUSION

Sacrum is an important bony for identification of sex in humans. The accuracy of determination of sex increases when maximum number of parameters is taken into consideration. So in the present study various parameters of the sacrum were determined and analyzed in detail in order to find their significance to determine the sex of unknown sacra accurately. Some the parameters like Length of Sacrum (L), Curved Length of Sacrum (CL) and Sacral Index (SI) were of very useful parameters as these values were stastically significant, however the sacral index still remains very useful indicator as noted previously by many authors. Also, the calculation of demarking points helps in sexing the sacrum with greater accuracy.

So the authors suggest that along with the sacral index, these parameters could be added with increases the accuracy of se determination. Also different other parameters like Length of ala of Sacrum, Alar index etc and so many other parameters can be added so that the estimation may be 100% accurate. Also, the various parameters obtained in the present study would be of very much useful to anatomists, forensic experts and anthropologists of Karnataka population.

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Conflicts of Interests: None

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