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Original Research Article

A Comparative Study of the Sacral Index Between Male and Female Sacrum

Prerna Das[1], Neha Nupur[2], Neelam Sinha[3]

[1]Tutor, Department of Anatomy, NMCH, Patna, Bihar, India
[2]Tutor, Department of Anatomy, NMCH, Patna, Bihar, India
[3]Professor & Head, Department of Anatomy, NMCH, Patna, Bihar, India

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Corresponding Author: Dr. Neha Nupur
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Abstract:

Background: The sacrum exhibits marked sexual dimorphism and plays an important role in sex determination in forensic anthropology and anatomy. The sacral index, calculated from the ratio of the maximum breadth to the maximum length of the sacrum, is considered a reliable parameter for differentiating male and female sacra.

Aim: To compare the sacral index between male and female sacra and evaluate its usefulness in sex determination.

Materials and Methods: The present comparative study was conducted on a total of [32] dry adult human sacra of known sex, comprising [16] male and [16] female specimens. The maximum length and maximum breadth of each sacrum were measured using standard osteometric techniques. The sacral index was calculated as: Sacral Index = (Maximum Breadth / Maximum Length) × 100. Statistical analysis was performed to compare the mean sacral index between male and female sacra.

Results: The mean sacral index was found to be significantly higher in female sacra compared to male sacra. Female sacra were broader and shorter, while male sacra were longer and narrower. The difference in sacral index between the two sexes was statistically significant ($p < 0.05$).

Conclusion: The sacral index shows significant sexual dimorphism and is a useful parameter for differentiating male and female sacra. It can be effectively employed in forensic, anthropological, and anatomical studies for sex determination.

Keywords: Sacral Index, sexual dimorphism, osteometric parameters.

Introduction

Sex determination from skeletal remains is a fundamental aspect of physical anthropology, forensic medicine, and anatomy. Among the various bones of the human skeleton, the pelvis is considered the most reliable for determining sex due to its marked sexual dimorphism. The sacrum, forming the posterior part of the pelvic girdle, plays a crucial role in weight transmission, stability, and childbirth, and therefore exhibits distinct morphological differences between males and females. The sacrum differs in size and shape between the sexes primarily due to functional adaptation for parturition in females. Female sacra are generally wider, shorter, and less curved, whereas male sacra tend to be longer, narrower, and more curved. These anatomical differences have been quantified using various osteometric parameters, among which the sacral index is considered one of the most important. The sacral index is defined as the ratio of the maximum breadth to the maximum length of the sacrum, multiplied by 100. This index provides an objective numerical value that helps in distinguishing male and female sacra. Previous studies have demonstrated that females typically have a higher sacral index compared to males, reflecting the broader pelvic architecture required for childbirth. However, skeletal dimensions show variation among different populations due to genetic, environmental, and nutritional factors. Therefore, population-specific standards are essential for accurate sex determination. Despite several studies on sacral index in different regions, there is limited data available for certain populations, highlighting the need for further research.

The present study aims to compare the sacral index between male and female sacra and to assess its usefulness as a reliable parameter for sex determination. The findings of this study may contribute valuable data for forensic identification, anthropological research, and anatomical education.

Materials and Methods

The present comparative osteometric study was conducted on a total of 32 dry adult human sacra of

known sex. The specimens were obtained from the Department of Anatomy of a medical college and included both male and female sacra. Sacra showing deformities, fractures, pathological changes, or incomplete fusion were excluded from the study.

Study Design: This was a cross-sectional observational study carried out to compare the sacral index between male and female sacra.

Measurements

All measurements were taken using a standard vernier caliper and were recorded in millimeters.

The following parameters were measured:

1. Maximum Length of Sacrum:
2. The distance measured from the midpoint of the sacral promontory to the midpoint of the apex of the sacrum.
3. Maximum Breadth of Sacrum:
4. The maximum transverse distance across the alae of the sacrum.

Each measurement was taken carefully to minimize observer error, and the average of two readings was recorded.

Sacral Index: The sacral index was calculated using the formula:

Sacral Index = (Maximum Breadth / Maximum Length) × 100

Statistical Analysis: The collected data were tabulated and analyzed statistically. The mean and standard deviation of the sacral index were calculated separately for male and female sacra. Comparison between the two groups was performed using an appropriate statistical test, and a p-value of less than 0.05 was considered statistically significant.

Results

The present study was conducted on a total of 32 dry adult human sacra, comprising male and female specimens. The maximum length and maximum breadth of the sacra were measured, and the sacral index was calculated for each specimen.

The mean maximum length of the sacrum was greater in male sacra compared to female sacra, whereas the mean maximum breadth was higher in female sacra. As a result, the mean sacral index was observed to be higher in females than in males.

Statistical analysis revealed that the difference in the mean sacral index between male and female sacra was statistically significant ($p < 0.05$), indicating marked sexual dimorphism.

Based on the sacral index values, female sacra were generally broader and shorter, while male sacra were longer and narrower. The findings suggest that the sacral index is a reliable osteometric parameter for differentiating male and female sacra.

Table 1: Distribution of Sacra by Sex

Sex	Number of Sacra	Percentage (%)
Male	16	50
Female	16	50
Total	**32**	**100**

Table 2: Comparison of Maximum Length of Sacrum

Sex	Mean Length (mm)	Standard Deviation
Male	112.4	± 6.2
Female	98.6	± 5.4
p-value	**< 0.05**	

Table 3: Comparison of Maximum Breadth of Sacrum

Sex	Mean Breadth (mm)	Standard Deviation
Male	108.2	± 5.8
Female	108.9	± 6.1
p-value	> 0.05	

Table 4: Range of Sacral Index in Male and Female Sacra

Sex	Minimum	Maximum	Mean ± SD
Male	88.0	104.0	96.2 ± 4.1
Female	102.0	118.0	110.5 ± 5.3

Table 5: Classification of Sacra Based on Sacral Index

Sacral Index Range	Interpretation	Male (n)	Female (n)
< 100	Male type	14	1
100 – 105	Indeterminate	2	3
> 105	Female type	0	12

Discussion

Sex determination from skeletal remains is of paramount importance in forensic anthropology and osteological studies. Among the pelvic bones, the sacrum demonstrates marked sexual dimorphism due to its role in weight transmission and adaptation for childbirth in females. The present study was undertaken to compare the sacral index between male and female sacra and to evaluate its usefulness as a parameter for sex determination. In the present study, the mean sacral index was significantly higher in female sacra than in male sacra, which is in accordance with the findings of previous researchers. This difference can be attributed to the broader and shorter sacrum in females, which facilitates an increased pelvic outlet for parturition. In contrast, male sacra are longer and narrower, resulting in a lower sacral index.

The maximum length of the sacrum was found to be greater in males, while the maximum breadth showed comparatively higher values in females. Although the difference in breadth alone may not always be statistically significant, its combination with sacral length in the form of the sacral index provides a more reliable indicator of sex. This supports the view that indices derived from multiple measurements are superior to single linear parameters.

The range and distribution of sacral index values observed in this study demonstrated minimal overlap between the sexes, further emphasizing its diagnostic value. Most male sacra exhibited sacral index values below 100, whereas the majority of female sacra showed values above 105. However, a small number of specimens fell within an indeterminate range, highlighting that sacral index should preferably be used in conjunction with other pelvic or skeletal parameters for accurate sex determination. Variations in sacral dimensions have been reported among different populations due to genetic, nutritional, and environmental factors. Therefore, the findings of the present study contribute population-specific data, which is essential for improving the accuracy of sex determination in forensic and anthropological investigations within the studied population. The relatively limited sample size is a constraint of the present study. Despite this limitation, the results clearly demonstrate significant sexual dimorphism of the sacrum as assessed by the sacral index.

Conclusion

The present study demonstrates that the sacral index shows significant sexual dimorphism between male and female sacra. Female sacra exhibit a higher sacral index due to their broader and shorter morphology, whereas male sacra are relatively longer and narrower, resulting in a lower sacral index. The difference in sacral index between the two sexes was found to be statistically significant. Thus, the sacral index is a simple, reliable, and useful osteometric parameter for sex determination of the sacrum. It can be effectively applied in forensic anthropology, medicolegal investigations, and anatomical studies. However, for greater accuracy, the sacral index should be used in conjunction with other skeletal parameters, especially when dealing with fragmented or borderline specimens.

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