

Sexual Dimorphism with Help of Sacrum

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Abstract: Sex determination of a skeleton is a problem of concern to paleoanthropologists, paleodemographers & forensic scientists. Pelvic bones are most important for sex determination, followed by skull & the long bones. Forensic expert is often faced with a single specimen on whom he is asked to pronounce an opinion about its origin in general terms; or it may be necessary to establish as probably belonging to a given person when the identity is already suspected on circumstantial evidence. 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. Otherwise, a female bone could be classified as a male when the series to which it belonged was particularly robust. The sacrum has always attracted the attention of the medico-legal experts for establishing its sex, because of its contribution to pelvic girdle and associated functional sex differences. Thus sacrum assumes an applied importance in determining sex with the help of measurements carried upon it.

Keywords: Sex Determination, Bones, Sacrum, Parameters

1. Introduction

The human sacrum is a large, triangular bone fusion of five vertebrae and forms the posterosuperior wall of the pelvic cavity, wedged between the two hip bones. The sacrum has always attracted the attention of medico-legal experts for establishing the sex. It is an integral part of the axial skeleton and contributes to the functional sex differences of the pelvic girdle between the two genders. It supports the erect spine and provides the strength and stability of the bony pelvis to transmit the body weight and also allows considerable mobility in childbearing [1].

In humans, the upper part of the sacrum connects with the last lumbar vertebra, and its lower part with the coccyx (tailbone) via the sacral and coccygeal cornu. Usually, it begins as five unfused vertebrae which begin to fuse between the ages of 16–18 years and have usually completely fused into a single bone by the age of 34 years.

The sacrum has three different surfaces which are shaped to accommodate various structures. It articulates with four other bones. It is curved upon itself and placed obliquely (tilted forward). It is concave, facing forward. The base projects forward as the sacral promontory internally, which is the uppermost portion of the sacrum. The central part is curved outward toward the posterior, allowing greater room for the pelvic cavity. The two lateral projections of the sacrum are called the alae (wings), and articulate with the ilium at the L-shaped sacroiliac joints [2].

2. Reason for Choice of Sacrum in Sex Determination

There are congenital disorders that develop in the early stages of the fetus. The sacrum is a large, triangular fusion of five vertebrae and forms the posterosuperior wall of the pelvic cavity, wedged between the two innominate bones.³Neuroradiologists study the sacrum as a continuation of the spinal axis whereas pediatric radiologists evaluate the sacrum as part of the skeletal system and cross-sectional abdominal radiologists often assess the sacrum as a posterior

border of the pelvis.⁴ Morphometric estimation of sex from the pelvic bones becomes particularly important when dealing with incomplete or fragmented remains or cases where the morphology is ambiguous. In forensic or archaeological context estimation of sex is a very important step in the identification of any human skeletal remains discovered. The Sacrum (L. sacer: sacred) supports the erect spine, provides the strength and stability of the bony pelvis to transmit the body weight and also allows considerable mobility in childbearing. The bones of the body are the last to perish after death, next to the enamel of teeth. Sex determination of skeletal material is of concern to anatomists, anthropologists, paleoanthropologists, paleodemographers and forensic scientists [5].

3. Characteristic Features for Sexual Dimorphism

In the determination of personal individuality from adult human skeletal remains, the pelvis affords the best marked and reliable characteristics for distinguishing sex in 90% - 95% subjects [6]. The sacrum has always enjoyed the attention of medicolegal experts for establishing the sex due to its contribution to the pelvic girdle and associated sex differences which are augmented due to reproductive functions, mainly influenced by sex hormones. The female sacra are shorter and wider, providing a wider pelvic cavity [7].

As part of the bony pelvis, the sacrum is expected to show sexual dimorphism in order to meet the reproductive needs of females while allowing for proper bipedal locomotion in both sexes (Flander, 1978; 1980)⁸. Due to its position at the base of the vertebral column and the necessity of weight bearing and up-right posture capabilities, the degree of dimorphism between male and female sacra is not as distinct as that seen in the oscoxa. [9] Analyses conducted in the first half of the 20th century account for much of the information available on sex differences in the sacrum and are often included as part of broader research focusing on population differences (Flander, 1978) [8]. Studies of sexual dimorphism of the sacrum have also generally been

conducted on living persons and cadavers and rarely on dry bone, making the anthropological literature on the sacrum sparse.

4. Parameters Used For Assessment

Parameters included were Maximum length of sacrum, Maximum breadth (width) of sacrum, Midventral curved length, Transverse diameters of the body of first sacral vertebra, Anteroposterior diameters of the body of first sacral vertebra, Maximum Length of auricular surface, Maximum width of auricular surface (AS), Mid diameter of auricular surface, Location of apex of sacral hiatus, Location of base of sacral hiatus, Length of sacral hiatus, Antero posterior diameters of sacral canal at the level of apex, Transverse diameters at the level of cornu, Shape of Sacral hiatus. Parameters were measured by using standard method. Sacral width, as a percentage of length, yields a Sacral index. On the basis of this index, the sacrum can be divided into three groups (vide Wilder's manual of Anthropometry) [10]:

- i) Dolichohieric: sacral index < 100 (up to 99.99)
- ii) Sub-plathyhieric: sacral index is in between 100 -106.
- iii) Plathyhieric: sacral index > 106.

5. Discussion

There have been numerous studies linked to the reliability of sex estimation through the quantitative assessments of sexual dimorphic traits of the sacrum (Flander 1978) [8]. With the sacrum being designated as a portion of the pelvic girdle, which is a known reliable and frequently used means of estimating sex, the sacrum's location and function does imply that it may also have potential in sex estimation. In order for the pelvic inlet of females to be enlarged for the accommodation of child rearing, it has been proposed that female sacra exhibit a lesser degree of sacral curvature which would be useful in sex estimation (Plochocki 2010) [11]. Recent research into the sexual dimorphism of the sacrum has focused on the subtense or degree of curvature at various points along the anterior surface, as well as the traditional anterior lengths and breadths measurements of the sacrum.

Also, Flander (1978) found that one of the most significantly sexual dimorphic traits to be the anterior straight breadth of the sacrum at the first sacral vertebra. The reliability of the maximum sacral breadth as sexually dimorphic is somewhat controversial, with some researchers finding it an accurate representation of sex, while others claim that the measurement is unusable in sex estimation (Benazzi et al. 2009) [12].

Research suggests that the sacrum not only exhibits sexually dimorphic patterns, but that the accuracy of sex estimation differs in each sex, with this accuracy also being influenced by morphological variation associated with group affiliation. It has been demonstrated that Black females are the most positively correlated with sexually dimorphic measurements of the sacrum, with the accuracy in a study conducted by Moore-Jansen and Plochocki being in the 96th percentile. While still highly reliable, the accuracy of sex estimation in the White female sample of this study was 88%. The male

samples of both group affiliations, however, were not proven to be reliable, with 58% of Black males and 53% of White males being correctly classified

6. Summary & Conclusions

Since sacrum is a component of pelvic girdle with functional differences between the two sexes, it itself becomes important for identification of sex in the human skeletal system. Are found to be, out of the seven parameters of the sacrum, five parameters yielded significant mean differences between the two sexes. These were Midventral straight length, Midventral curved length, Transverse diameter of base, Antero-posterior diameter of body of S1 and Breadth of alae ; all being more in the males as compared with females. Sex differences are more in line with the robusticity of the male skeleton. While most of the results were in line with the previous workers, the Breadth of Alae & Corporobasal Index gave contrasting results. The alae were wider in males and the corporobasal index was more in females. Summary & Conclusions: Since sacrum is a component of pelvic girdle with functional differences between the two sexes, it itself becomes important for identification of sex in the human skeletal system. Out of the seven parameters of the sacrum, five parameters yielded significant mean differences between the two sexes. These were Midventral straight length, Midventral curved length, Transverse diameter of base, Antero-posterior diameter of body of S1 and Breadth of alae ; all being more in the males as compared with females. Amongst the indices the Sacral index yielded significant results, but was more in the females. Thus sex differences are found to be found to be more in line with the robusticity of the male skeleton. While most of the results were in line with the previous workers, the Breadth of Alae & Corporobasal Index gave contrasting results. The alae were wider in males and the corporobasal index was more in females.

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