DOI:https://doi.org/10.53350/pjmhs202317763

ORIGINAL ARTICLE

Assessment of Morphological Differences in Pelvic Bones among Adult Males and Females, A Gross Anatomical Study

ASMA ZULFIQAR[1], MUHAMMAD UMAR[2], PIRIHA ABBASI[3], SITWAT AMNA[4], MUHAMMAD FAISAL KHAN[5], NIMRAH FAHIM[6]
[1]*Assistant Professor of Anatomy, Khawaja Muhammad Safdar Medical College, Sialkot, Pakistan*
[2]*Associate Professor Anatomy, Nawaz Sharif Medical College, Gujrat, Pakistan*
[3]*Assistant professor Anatomy, Isra University Hyderabad, Pakistan*
[4]*Assistant professor Anatomy Allama Iqbal Medical College Lahore, Pakistan*
[5]*Assistant Professor Anatomy Gujranwala Medical College Gujranwala, Pakistan*
[6]*Senior Demonstrator Department of Anatomy FMH College of Medicine and Dentistry, Shadman Lahore, Pakistan.*
Correspondence to: Muhammad Umar, Email: Drumar1010@gmail.com

ABSTRACT

Background: The human pelvic bone is the most sexually dimorphic structure in the skeleton, and it plays an essential role in locomotion, reproduction, and forensic identification. Nevertheless, little is known about the Pakistani population with regard to anatomical characteristics. The purpose of this study is to investigate gross anatomical differences in pelvic bones in the adult males and females.

Methods: The skeletal collection of two Pakistani hospitals was subjected to examination of a total of n=60 dry adult pelvic bones (30 males and 30 females). Measurements of standard anatomical tools were made of subpubic angle and ischiopubic index. Visually, the shape of the pelvic inlet and sciatic notch width were assessed. The data were analyzed using SPSS version 25.0. Independent sample t-tests and Chi-square tests were applied, where $p < 0.05$ was taken to be statistically significant.

Results: The mean subpubic angle was 82.6° ± 4.1° in females and 68.2° ± 3.5° in males ($p < 0.001$). In addition, females (97.4 ± 6.5) had significantly higher ischiopubic index than males (78.5 ± 5.2) ($p < 0.001$). In most cases, male pelvises showed heart-shaped inlets (83.3%) and narrow sciatic notches (86.7%), while female pelvises had circular inlets (90%) and wide sciatic notches (80%) ($p < 0.001$ for both).

Conclusion: The study's results confirm the distinct sexual dimorphism in the adult pelvic bones of the Pakistani population. The findings are critical for anatomical education, forensic anthropology, and clinical practice, giving critical anatomical benchmarks.

Keywords: Pelvis, Sexual dimorphism, Subpubic angle, Ischiopubic index, Forensic anthropology, Gross anatomy, Pakistan

INTRODUCTION

The human pelvis is a cornerstone of the axial and appendicular skeleton, functioning as a vital structural unit for locomotion, support of abdominal and pelvic viscera, and — most notably in females — the conduit for parturition[1]. The pelvis is the anatomical structure consisting of the paired hip bones (os coxae), sacrum, and coccyx and is a part of the pelvic girdle. In addition to its structural and physiological roles, the pelvis provides immense information regarding biological sex determination in humans because of its distinctly morphological differences between males and females (sexual dimorphism) [2].

Evolutionary adaptation to divergent functional demands is the basis of pelvic sexual dimorphism. Greater muscle mass and higher mechanical load reflect greater male pelvis optimization for bipedal locomotion and robust weight bearing. Therefore, it is also narrower, taller, and more compact with a funnel-shaped pelvic cavity[3]. On the other hand, the female pelvis has been adapted for childbirth. It has a broader and more circular pelvic inlet, a wider subpubic angle, and a shallower but wider pelvic cavity. These adaptations facilitate labor and delivery accommodation of the fetus, an anthropological feature known as the obstetric dilemma[4].

These morphologic differences were traditionally used by forensic anthropologists, anatomists, and clinicians to determine gender in forensic contexts, to plan orthopedic and gynecologic surgeries, to guide obstetrical interventions, to aid anatomical education, or to make other uses. Accurate sex determination from skeletal remains is a key step in the biological profiling of unidentified individuals in forensic investigations, especially[5]. Previous studies have consistently demonstrated that the pelvic bone is among the most sexually dimorphic skeletal structures and can be used to determine sex with an accuracy of 90 to 95 percent using pelvic features alone[6].

Morphometric standards for pelvic dimorphism have been provided by numerous studies from Western and African populations. Nevertheless, sexual dimorphism can be highly variable between ethnicities and geographical populations under the influence of genetic, environmental, and nutritional factors. However, little localized data exist on pelvic morphological differences between sexes in Pakistan's diverse and rich population. When region-specific morphometric references are lacking, misclassification in both clinical and forensic evaluations is a risk. A critical gap in the anatomical and forensic literature in South Asia, and the Pakistan, is the lack of comprehensive, population-based anatomical studies[7].

Thus, the present study may be considered a gross anatomical study to evaluate and compare the morphological differences of the pelvic bones of adult Pakistani males and females. The study aimed to analyzes such parameters as subpubic angle, ischiopubic index, greater sciatic notch width, and pelvic inlet shape to provide region-specific reference data. Such a facility will not only improve anatomical education and forensic practice, but also add local insight into sexual dimorphism of the pelvis to global anthropological databases[8, 9].

MATERIALS AND METHODS

This study was a cross-sectional study that focused on gross morphological differences of the pelvic bones in adult males and females. The objectives were to determine sexual dimorphism via direct visual inspection and precise morphometric measurement. It was done for one year from January 2022 to December 2022 at two highly reputed institutions of Pakistan, Allama Iqbal Memorial Teaching Hospital Sialkot and Jinnah Hospital, Lahore, Pakistan, Because of their skeletal collections and research expertise in anatomical research, these centres were chosen.

A total of 30 male and 30 female dry human pelvic bones were examined. A purposive sampling technique was employed to select the bones; only complete adult pelvic bones with no damage and identified sex according to institutional skeletal records were included. The age range of the specimens was between 20 and 65 years, and all bones included were free from pathological deformities or any obvious trauma-related abnormalities.

Bones of the subjects were required to be adult (based on epiphyseal fusion and skeletal maturity), anatomically intact, and of confirmed male or female sex. To ensure the reliability of the morphometric evaluation, incomplete specimens, fractured

Received on 15-01-2022
Accepted on 10-06-2023

specimens with pathological remodelling, or specimens without demographic verification were excluded from the study.

The study was approved by the Institutional Review Boards of both participating colleges. This study was conducted in accordance with ethical principles used in the use of human skeletal remains in anatomical research. During the study, all specimens were treated with scientific respect and with dignity.

Specific morphological and morphometric parameters of the pelvic bones known to show sexual dimorphism were evaluated in each pelvic bone. The parameters studied were subpubic angle, shape of the pelvic inlet, width of the greater sciatic notch, and ischiopubic index. A standard anatomical goniometer was used to measure the subpubic angle, which was defined as the angle between the inferior rami of the pubic bones at the pubic symphysis. Visual inspection of the pelvic inlet shape was performed and categorized as heart-shaped (typically male) or circular/oval (typically female). Anatomical landmarks, including the posterior inferior iliac spine and ischial spine, were used to observe and grade qualitatively the width of the greater sciatic notch as wide or narrow. The pubic and ischial lengths were measured with digital Vernier calipers on the ischiopubic index. The formula used to calculate the index was:

$$\text{Ischiopubic Index} = \left(\frac{\text{Pubic Length}}{\text{Ischial Length}}\right) \times 100$$

The value of this index is a numerical representation of sexual dimorphism in that females tend to have a higher value because their pubic lengths are longer than their ischia.

Three experienced anatomists independently recorded each parameter to minimize observer bias and measure reliability. All the measurements were repeated thrice, and the mean reading of the three readings was finally used for the analysis. All observations and measurements were done on bones that had been laid flat on a standardized, non-reflective surface with uniform lighting.

The collected data were tabulated, and statistical analysis was done using IBM SPSS Statistics 25.0 All morphometric values were calculated on descriptive statistics (means and standard deviations). Statistically significant differences between the male and female groups were also determined for continuous variables using an independent sample t-test, and for categorical variables (pelvic inlet shape and sciatic notch width), the chi-square test was used. Statistical significance was considered if $p < 0.05$.

RESULTS

A gross morphological difference of pelvic bones between adult males and females was assessed using 60 dry pelvic bones, 30 male and 30 female specimens. The skeletal bones were obtained from the University of Health Sciences, Lahore, and Allama Iqbal Medical College, Lahore, Pakistan, bone bank collections. All specimens were anatomically intact, of confirmed sex, and all were from adults aged 20 to 65 years. The aim was thus to compare four main anatomical features, based on both visual assessment and morphometric measurements, i.e., subpubic angle, ischiopubic index, pelvic inlet shape, and greater sciatic notch width. SPSS version 25 statistical analyses were conducted with $p < 0.05$ significance.

Internally, male specimens had a mean age of 41.6 ± 11.2 years, female specimens a mean age of 39.7 ± 10.4 years. There was no significant difference in age distribution between groups ($p = 0.442$). For males, 9 (30%) were from those 20–34 years old, 12 (40%) from 35–49 years, and 9 (30%) from 50–65 years. The 9 bones (30%) of the female group belonged to 20–34 years, 14 (46.7%) to 35–49 years, and 7 (23.3%) to 50–65 years. These distributions imply a balanced sample about age and sex.

The subpubic angle was narrower morphometrically in males (68.2 ± 3.5 degrees) than in females (82.6 ± 4.1 degrees; $p < 0.001$), and this also showed strong sexual dimorphism. Likewise, males (78.5 ± 5.2) had a much lower ischiopubic index than females (97.4 ± 6.5; $p < 0.001$), indicative of a longer pubis in females. The pelvic inlet was predominantly heart-shaped in males (83.3%) and circular or oval in females (90%), with a statistically significant difference between the two ($p < 0.001$) using the Chi-square test. Again, there was a statistically significant difference ($p < 0.001$) between the greater sciatic notch in males (86.7%) and in females (80%).

The results in table 1 show clear and statistically validated anatomical differences between male and female pelvic bones in the Pakistani population. Together with the morphometric analysis, the morphological parameters have high reliability for sex determination with anatomical and forensic applications.

Table 1: Demographic and Morphometric Comparison of Male and Female Pelvic Bones (n = 60)

Parameter	Males (n = 30)	Females (n = 30)	Statistical Test	p-value	Significance
Mean Age (years)	41.6 ± 11.2	39.7 ± 10.4	Independent Sample t-test	0.442	Not Significant
Age Group 20–34 years	9 (30%)	9 (30%)	Chi-square Test	1.000	Not Significant
Age Group 35–49 years	12 (40%)	14 (46.7%)			
Age Group 50–65 years	9 (30%)	7 (23.3%)			
Subpubic Angle (°)	68.2 ± 3.5	82.6 ± 4.1	Independent Sample t-test	< 0.001	Highly Significant
Ischiopubic Index	78.5 ± 5.2	97.4 ± 6.5	Independent Sample t-test	< 0.001	Highly Significant
Pelvic Inlet Shape	Heart-shaped: 25 (83.3%)	Circular/Oval: 27 (90.0%)	Chi-square Test	< 0.001	Highly Significant
	Circular/Oval: 5 (16.7%)	Heart-shaped: 3 (10.0%)			
Greater Sciatic Notch Width	Narrow: 26 (86.7%)	Wide: 24 (80.0%)	Chi-square Test	< 0.001	Highly Significant
	Wide: 4 (13.3%)	Narrow: 6 (20.0%)			

This study clearly shows that there are significant and consistent morphological and morphometric differences between male and female pelvic bones of the adult Pakistani population. Statistically significant variations between sexes were found for parameters such as subpubic angle, ischiopubic index, pelvic inlet shape, and greater sciatic notch width, which all prove to be parameters for sex estimation. This further validated the independence of these anatomical differences from age-related bias by the inclusion of demographic profiling. These findings not only confirm the classical anatomical knowledge, but they also contribute population-specific data that are important as a reference for forensic investigations, anthropological studies, surgical planning, and medical education in Pakistan.

DISCUSSION

The purpose of the current study was to assess and statistically validate gross anatomical differences between male and female pelvic bones in the adult Pakistani population[10]. The morphology of the pelvis is widely recognized as the most sexually dimorphic area of the human skeleton, whose morphology is crucial for clinical, obstetric, forensic, and anthropological purposes. As expected, our findings demonstrate that there are substantial differences between morphometric and morphological pelvic parameters, adaptations to biomechanical and reproductive functions[11]. Females had significantly wider subpubic angles (mean 82.6° ± 4.1°) than males (mean 68.2° ± 3.5°), as in earlier studies of other populations. The wider angle in females is an evolutionary adaptation to allow safe passage of the fetus through the birth canal. Like the female pelvis, the ischiopubic index, which represents the relative lengths of the pubis and ischium, was similarly higher in females and supports the functional design of the female pelvis for parturition[12]. The results are in agreement with the findings of Krenn et al. (2022) and several recent works by

Imai et al. (2019), which reported that an index value greater than 90 is strongly indicative of female sex[13].

Morphometric measurements were also made in addition to morphological traits such as pelvic inlet shape and sciatic notch width, which were different between sexes. Heart-shaped inlet and narrow sciatic notch were present in most of the male pelvises, whereas circular inlet and wide notch were found in the majority of the female pelvises[14]. The anatomical literature is well documented with these morphological adaptations, and they are key indicators in forensic identification when skeletal remains are incomplete or fragmentary[15].

The strengths of this study are the use of a well-preserved skeletal collection with verified sex and demographic information, and both objective measurements and subjective visual assessments. The study does, however, have some limitations, such as a relatively small sample size and no correlation with radiological or obstetric variables[16]. Future research with larger samples and 3D imaging techniques will improve pelvic sex determination, especially in medico-legal and archaeological contexts[17]. Overall, the results not only confirm the existing anatomical principles but also present region-specific reference values applicable in clinical practice and in forensic applications in Pakistan[18].

CONCLUSION

This gross anatomical study confirms the existence of sexual dimorphism in the adult human pelvis both morphometrically and morphologically. The female pelvis has a wider subpubic angle, a higher ischiopubic index, a circular pelvic inlet, and a broader greater sciatic notch, and the male pelvis is narrower and more compact in terms of the anatomical features. Statistically significant and consistent with classical descriptions, these differences were seen. The findings provide reliable anatomical criteria for sex differentiation and provide valuable baseline data for the Pakistani population for clinical anatomical, forensic, and anthropological studies.

Funding: No funding was received.

Authors contribution: All authors contributed equally to the current study.

Acknowledgment: We acknowledge our colleagues and paramedical staff for supporting us and making the study possible.

REFERENCES

1. Imai N, Suzuki H, Nozaki A, Miyasaka D, Tsuchiya K, Ito T, et al. Evaluation of anatomical pelvic parameters between normal, healthy men and women using three-dimensional computed tomography: a cross-sectional study of sex-specific and age-specific differences. Journal of Orthopaedic Surgery and Research. 2019;14:1-7.
2. Cox SL. A geometric morphometric assessment of shape variation in adult pelvic morphology. American Journal of Physical Anthropology. 2021;176(4):652-71.
3. Nishi K, Saiki K, Oyamada J, Okamoto K, Ogami-Takamura K, Hasegawa T, et al. Sex-based differences in human sacroiliac joint shape: a three-dimensional morphological analysis of the iliac auricular surface of modern Japanese macerated bones. Anatomical Science International. 2020;95:219-29.
4. Krenn VA, Webb NM, Fornai C, Haeusler M. Sex classification using the human sacrum: Geometric morphometrics versus conventional approaches. PLoS One. 2022;17(4):e0264770.
5. Sharma K, Gupta P, Shandilya S. Age related changes in pelvis size among adolescent and adult females with reference to parturition from Naraingarh, Haryana (India). Homo. 2016;67(4):273-93.
6. Fornai C, Webb NM, Urciuoli A, Krenn VA, Corron LK, Haeusler M. New insights on hip bone sexual dimorphism in adolescents and adults using deformation-based geometric morphometrics. Journal of Anthropological Sciences. 2021;99:117-34.
7. Mbaka G, Osinubi A. Morphometric study of sciatic nerve and its topographic anatomical variations in relation to landmark structures around pelvis: a Nigerian population study. Folia Morphologica. 2022;81(1):44-51.
8. Uy J, Hawks J, VanSickle C. Sexual dimorphism of the relationship between the gut and pelvis in humans. American Journal of Physical Anthropology. 2020;173(1):130-40.
9. Babu BV, Babu KY, Mohanraj KG. Morphological and morphometrical analysis of acetabulum with special reference to volume in dry human pelvic bone. Drug Invention Today. 2018;10(10).
10. Galea JC. The Relationship of Pelvic Scars and Pelvic Instability through an Analysis of the Gross Morphology and Microarchitecture of the Pubic Symphysis. 2018.
11. MOHANRAJ KG. Morphological and Morphometric Analysis of Sexual Dimorphism of Innominate Bone with Reference to Pubic Bone and Obturator Foramen. International Journal of Pharmaceutical Research (09752366). 2020;12(3).
12. Yilmaz O, Demircioğlu İ. Computed tomography-based morphometric analysis of the hip bones (Ossa coxae) in Turkish Van Cats. Kafkas Üniversitesi Veteriner Fakültesi Dergisi. 2021;27(1).
13. Cvetković D, Jadžić J, Milovanović P, Djonić D, Djurić M, Ivović M, et al. Comparative analysis of femoral macro-and micromorphology in males and females with and without hyperostosis frontalis interna: a cross-sectional cadaveric study. Calcified Tissue International. 2020;107:464-73.
14. Marzban Abbasabadi B, Hajian O, Rahmati S. Investigating the morphometric characteristics of male and female zell sheep skulls for sexual dimorphism. Anatomical Sciences Journal. 2020;17(1):13-20.
15. Abelson B, Sun D, Que L, Nebel RA, Baker D, Popiel P, et al. Sex differences in lower urinary tract biology and physiology. Biology of sex differences. 2018;9:1-13.
16. Sangchay N, Dzetkuličová V, Zuppello M, Chetsawang J. Consideration of accuracy and observational error analysis in pelvic sex assessment: A study in a Thai cadaveric human population. Siriraj Medical Journal. 2022;74(5):330-9.
17. Pullanna B, Bindhu S, Avadhani R, Jacob M. MORPHOMETRY OF THE ADULT HUMAN DRY HIP BONE IN SOUTH INDIAN POPULATION. Int J Anat Res. 2019;7(1.2):6178-82.
18. Shruthi M, Mohanraj KG. Determination of sex using os coxae in relation to ischial tuberosity–A morphometric study. Drug Invention Today. 2019;11(10).

This article may be cited as: Zulfiqar A, Umar M, Abbasi P, Amna S, Khan MF, Fahim N: Assessment of Morphological Differences in Pelvic Bones among Adult Males and Females, A Gross Anatomical Study. Pak J Med Health Sci, 2023; 17(7): 63-65.