

# Sex Determination through Pelvic Bone Using Anteroposterior Radiographs

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## ABSTRACT

**Objective:** The objective of the study was to evaluate the accuracy of the digital radiography technology for sex recognition of the selected participant group in Hyderabad, Sindh.

**Methodology:** Cross-sectional study conducted by the department of Forensic Medicine at Liaquat University of Medical and Health Sciences Jamshoro and Isra University Hyderabad at the outpatient of Liaquat University hospital, Hyderabad from February to May 2023. The study included male and female patients aged 18-50 years and was authorized by the Research and Ethics Committee LUMHS. Study participants were divided into two groups; male and female. Differences in pelvis bone fragments parameters like iliac height, inter-acetabular distance, pelvic inlet (breadth), acetabulum diameter, pubic length, Ischial length and ischio-pubic index on digital x-ray radiographs of both groups were examined and compared.

**Results:** A statistically significant difference ( $p < 0.05$ ) in bony prominence parameters including inter-acetabular distance, acetabular diameter, breadth of the pelvic inlet, pubic length, ischial length and ischio-pubic index was observed between group A and group B. The study revealed that the accuracy in recognizing male individuals through ilium height (68.8%), inter-acetabular distance (64.7%), and the pelvic inlet breadth (61.0 %).

**Conclusion:** The iliac height, inter-acetabular distance, pelvic inlet (breadth), inter-acetabular diameter, pubic length, Ischial length and ischio-pubic index on radiographs (x-rays) of pelvic bones are reliable parameters in sex determination with high precision.

**Key Words:** Digital Radiography, Forensic Anthropology, Gender Identity, Pelvic Bone

### Authors' Contribution:

<sup>1,2</sup>Conception; <sup>1</sup>Literature research; <sup>1</sup>manuscript design and drafting; <sup>3,4</sup>Critical analysis and manuscript review; <sup>5,6</sup>Data analysis; Manuscript Editing.

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## Introduction

In forensic medicine, establishing one's gender is regarded as one of the most important aspects of determining one's identity.<sup>1</sup> The shredding bodies before identification is a common practice in forensic sciences. Often, all that is left are skeleton fragments or bits of bodies. Identifying gender becomes more challenging and tough in certain situations.<sup>2</sup> Furthermore, legal sex identification

among teenagers and youngsters is a significant issue in civil, immigration, and criminal law. In actuality, it's not often easy to determine gender from decaying bones.<sup>3</sup> Radiography has advantages over three-dimensional (3D) cone beam computed tomography, including global accessibility, similarly low cost, and low radiation doses. The radiologist acts as a key in the identification process since the radiological examination is typically used for this

purpose. Radiographs have been widely used for identifying purposes in minor and big catastrophes for a long time.<sup>4</sup> In radiography and the field of forensic medicine, it is critical to ascertain a person's age, gender, and size. Radiologically, gender is determined utilizing bones such as the femur, pelvis, and skull. However, the pelvis is used for identification in these situations because most of the skeleton's bones are severely damaged by cremation.<sup>5</sup> The pelvic bone allows the most accurate human sex identification. The unique characteristics of the pelvis makes it a good location for forensic testing. With a precision of 95% when finished, it is undoubtedly among the most suitable bones in the human skeleton for establishing both gender and age. Additionally, it has been calculated that sex may be determined with 98% accuracy using the sub-pubic angle, ventral arc, and composite due to the evident variances between the pelvic bones of men and women.<sup>6,7</sup> Forensic anthropology places a high value on victim sex estimation, while sex determination from bones is always population-specific. The identification of gender using the morphology of the pelvic bone with the assistance of digital radiography is therefore beneficial in providing a simple, less expensive technique of determining gender identity. The current study was conducted with its significance in mind to evaluate the accuracy of the digital radiography technology for sex recognition of the selected participant group in Hyderabad, Sindh.

## Methodology

This cross-sectional study was conducted in collaboration between the Department of Forensic Medicine of Liaquat University of Medical and Health Sciences, Jamshoro and Isra University, Hyderabad, Sindh, Pakistan from February to May 2023. The Research and Ethics Committee (REC) of Liaquat University of Medical Sciences, Jamshoro, Sindh has approved the study. The participants of the study comprised of both sexes (males and

females) patients who visited the outpatient department of Liaquat University Hospital, Hyderabad having an age range between 18 and 50 years. The study excluded participants from other institutes, that didn't fulfill the inclusion criteria. Participants with any skeletal anomalies, known inherited or developed skeletal ailments, or injuries to the pelvic bone were disqualified. After getting informed consent and explaining purpose of study the participants were divided into strata of male and female (group A and B respectively), each group comprises of same number of participants. The digital x-ray machine was utilized to acquire an anteroposterior view of the pelvic bone, and the radiographs were calculated while the patient was supine and the focus film distance was equal to 100cm. The distance between the top and lower points of the iliac crest on an X-ray was used to calculate the height of the pelvis. The maximum vertical diameter of the acetabulum was calculated using the intramuscular distance, which was the distance between the left and right center points of the acetabulum. The distance between the two most lateral points of the most lateral crests was thought to be the pelvic breadth, whereas the pelvic inlet breadth was measured as the distance between the most lateral points of the pelvic inlet. On a radiograph, the pubic length was measured by drawing a straight line that extends from the medial end of the pubic symphysis to the centre of the triradiate cartilage. Whereas, the Ischial length was measured by drawing a straight line on a radiograph that is drawn from triradiate cartilage and is perpendicular to the line connecting the bilateral lower ischial tuberosities. Pubic length is divided by ischial length to get the ischiopubic index, which is then multiplied by 100. To assure accuracy, every measurement was made twice, with the average being recorded as the actual distance.<sup>8</sup> The SPSS software version 23.0 was used to computerize and statistically analyze the obtained data. Data was comprised of quantitative variables so are displayed as mean and standard

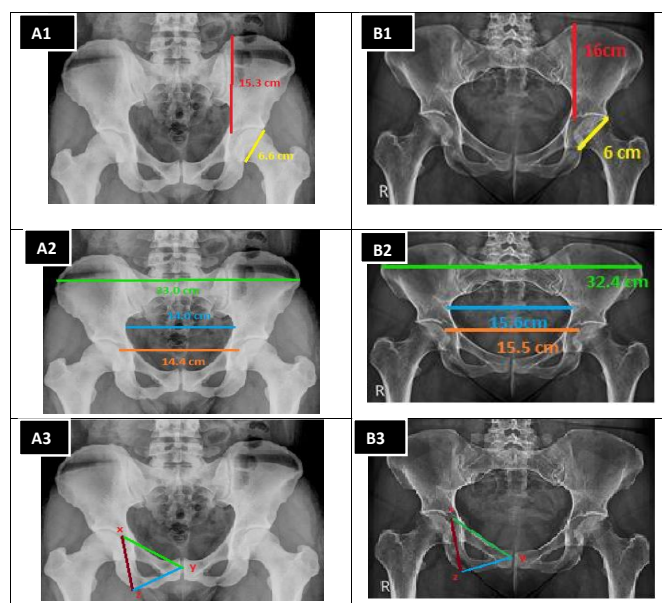
deviation (SD). Independent samples t-test was employed for the analysis of descriptive and inferential statistics. A p-value of <0.05 indicates a significance level.

## Results

The study had 168 people in total, who were split into two strata or subgroups: Group A had 84 male participants, while Group B had 84 female participants. The examined individuals' average ages ranged from 19 to 50 years old, with a mean of  $37.2 \pm 11.2$  years overall. While the average age of the male participants was  $38.0 \pm 12.0$  (20-50), the average age of the female participants was  $35.6 \pm 11.6$  (19-46). The mean ages of men and women did not significantly differ from one another. Table I demonstrates the group-wise comparison between the measures of the bony prominences on x-rays for participants in Group A and Group B. Except for pelvis (greatest breadth), statistically significant difference ( $p < 0.05$ ) of all other bony prominence was seen in parameters between A and B group.

Variable	Group A Mean $\pm$ SD	Min-max	Group B Mean $\pm$ SD	Min-max
Iliac height	15.2 $\pm$ 1.3	13.3-17.4	13.5 $\pm$ 0.9	12.2-15.8
Acetabulum diameter	6.6 $\pm$ 0.5	5.6-7.4	6.0 $\pm$ 0.5	5.1-7.4
Pelvis (Greatest breadth)	33.0 $\pm$ 3.4	28.3-38.6	32.4 $\pm$ 2.3	29.3-35.8
Pelvic inlet (Breadth)	14.1 $\pm$ 1.2	12.2-15.8	15.6 $\pm$ 1.6	13.8-16.8
Inter-acetabular distance	14.5 $\pm$ 1.2	12.5-15.8	15.5 $\pm$ 1.3	13.4-18.6
Pubic length	8.3 $\pm$ 0.8	6.4-10.2	9.3 $\pm$ 0.7	7.5-10.8
Ischial length	9.1 $\pm$ 0.6	7.6-11.8	8.4 $\pm$ 0.6	7.4-9.8
Ischio-pubic index	90.8 $\pm$ 6.0	81.3-102.4	111.5 $\pm$ 6.0	101.2-133.4

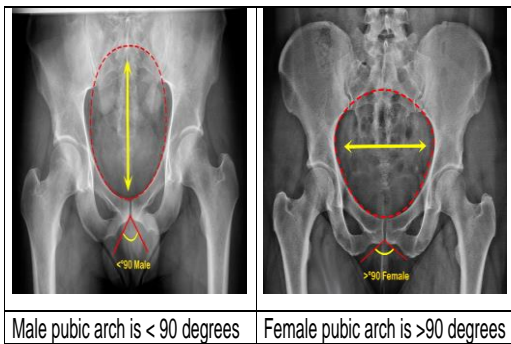
Figure 1 presents the anteroposterior view digital X-ray findings of the female (B1, 2 and 3) and male (A1, 2 and 3) pelvis. Based on the radiographic findings, the acetabular diameter (yellow line) and ilium height (red line) in male pelvis is significantly larger than the female (A1 and B1). From female pelvis radiograph (B2), a significant increase in pelvic inlet breadth (blue line) and Inter-acetabular distance (orange line) was demonstrated compared with their counterparts. While greatest breadth of pelvis (green line) is increased in male. Moreover, radiographs (A3 and B3) showing the pubic length (x-y) and ischial length (x-z) of both male and female. The pubic length was more among females compared to the males while ischial length of male was more compared to their counterparts.



**Figure 1: Digital X-ray Anteroposterior view of the female (B1, 2 and 3)**

The radiograph in figure 2 is showing the differences in angles of pubic arch in both groups. Based on findings, pubic angle was lesser in group A (males) compared to group B (female). Table II below shows the accuracy of the radiography in determining sex differences for forensic assessment. Specifically, the ilium height was examined, and it was found that when the cut-off value exceeded 13.75 mm, the

accuracy in identifying male individuals was determined to be 68.8%. Additionally, the inter-acetabular distance was assessed, and when the cut-off value was less than 14.95 mm, the accuracy in determining male gender was found to be 64.7%. Furthermore, the accuracy of diameter of acetabulum, namely the cut-off value exceeding 5.95 mm, was found to be 67.2% in determining male gender. Lastly, the study examined the pelvic inlet breadth, and it was observed that when the cut-off value was less than 15.05 mm, the accuracy in identifying male individuals was determined to be 61.0 %.



**Figure 2: Differences in angles of pubic arch in both groups**

Table II below shows the accuracy of the radiography in determining sex differences for forensic assessment. Specifically, the ilium height was examined, and it was found that when the cut-off value exceeded 13.75 mm, the accuracy in identifying male individuals was determined to be 68.8%. Additionally, the inter-acetabular distance was assessed, and when the cut-off value was less than 14.95 mm, the accuracy in determining male gender was found to be 64.7%. Furthermore, the accuracy of diameter of acetabulum, namely the cut-off value exceeding 5.95 mm, was found to be 67.2% in determining male gender. Lastly, the study examined the pelvic inlet breadth, and it was observed that when the cut-off value was less than 15.05 mm, the accuracy in identifying male individuals was determined to be 61.0 %.

	Cut off value	Sensitivity	Specificity	Accuracy	AUC (95% CI)
<b>Iliac height</b>	>13.75	71.3%	67.3%	68.8%	0.80 0.71-0.89
<b>Inter-acetabular distance</b>	<14.95	77.9%	50.7%	64.7%	0.71 0.60-0.75
<b>Acetabular Diameter</b>	>5.95	72.8%	61.0%	67.2%	0.69 0.61-0.80
<b>Pelvic inlet (Breadth)</b>	<15.05	70.3%	50.6%	61.0%	0.70 0.61-0.76
<b>Pubic length</b>	<8.55	72.3%	61.5%	67.7%	0.68 0.60-0.73
<b>Ischial length</b>	<8.75	73.2%	85.0%	71.3%	0.66 0.59-0.71
<b>Ischiopubic index</b>	102.03	89.5%	72.3%	73.0%	0.73 0.64-0.77

## Discussion

The specialized indicators seen in fragmented remains and decomposing corpses can be realistically addressed by forensic radiology.<sup>9</sup> The radiographic examination can become an effective predicting method to detect major disasters in a concluding population sign.<sup>10</sup> Gender in forensic medicine is determined by a number of bodily components, including the pelvis, long bones with epiphyses, and metaphysis in skeletons. The pelvis is likely the bodily part that can reliably tell us the age and gender of the deceased victim. Due to hormonal differences that impact bone formation, males and women have varied pelvic morphologies. It is believed that sex hormones like testosterone and estrogen have an impact on the development of the pelvis.<sup>11</sup> Courts and other government entities require forensic assessments of gender and age so that all court cases involving somebody's gender and age may be appropriately monitored.<sup>3</sup>

The purpose of this research was to determine the accuracy of the determination of gender using digital pelvic X-ray imaging in a population sample from Hyderabad, Pakistan. The sample included 168 patients, both male and female, whose ages ranged from 18 and 50 years. Our study demonstrated

different parameters like ilium height, acetabular diameter, interacetabular distance, pelvic inlet width, pubic length, ischial length, ischio-pubic index and pubic arch for differentiating male and female genders using pelvic x-rays of both genders. Different studies conducted on the significance of the pelvis for gender determination in Europe, India, and Africa reported significant differences between the pelvises of both sexes.<sup>1,6,12</sup> Moreover, these studies mentioned that they used a variety of approaches, such as measuring these parameters through similar measures for determining sex through X-rays as we did in the present study. In the present study, males' ilium height and acetabular diameter increased statistically significantly, as did the breadth of the pelvic inlet compared to their female counterparts while no significant difference was demonstrated in greatest breadth of pelvis. These findings are consistent with the findings reported by Varzandeh et al. and Abdullah et al.<sup>13,14</sup> The anterior acetabular ridges, acetabulum diameter, and acetabulum depth are critical factors in sex determination a number of investigations in forensic medicine.<sup>12</sup> Bubalo et al. reported that male had considerably higher acetabular diameter and trans-acetabular distance than females.<sup>(15)</sup> By utilizing various methodologies for sex estimation, Varzandeh et al. indicated that anterior acetabular ridges, acetabulum diameter, and acetabulum depth are relevant in determining one's sex.<sup>14</sup> Similar to these, our study also demonstrated the statistically significant ( $p < 0.05$ ) difference of the distance in acetabular diameter and trans-acetabular distance in both genders. The present study demonstrated on x-rays that males had significantly greater Ischial lengths than females ( $p < 0.05$ ) while female had substantially higher mean pubic length and ischiopubic index than male ( $p < 0.05$ ). These findings are consistent with the findings reported by different Pakistani and Indian studies.<sup>16</sup> When utilizing ROC curves to identify sex, the ilium height, inter-acetabular distance, pelvic inlet width, and acetabular diameter were calculated as reference

points. The inter-acetabular distance, acetabular diameter, and pelvic inlet breadth were all accurate in predicting the male sex with 68.6%, 64.1%, 66.7%, and 60.3% respectively. According to Varzandeh et al., the ilium height, acetabular diameter, pelvic inlet width, and interacetabular distance sex estimates had accuracy rates of 77%, 72%, 71%, and 67%, respectively. Our findings were lower than Varzandeh et al. while our study findings are consistent with Abdallah et al.<sup>13</sup> To the best of knowledge, such study is not yet conducted in the current settings. The present study was carried out on visitors of outpatient in one of the public hospitals in Hyderabad, Pakistan, so the results cannot be generalized to other groups of people. Furthermore, because assessments were taken from radiographic pictures, the real measurements of the framework of bones may not correlate with the current figures.

## Conclusion

In conclusion, the findings of the present investigation revealed that assessing factors such as the ilium height, inter-acetabular distance, pelvic inlet width, acetabular diameter, pubic length, Ischial length and ischio-pubic index on radiographs (x-rays) of pelvic bones are reliable bone fragments parameters in sex determination.

## References

1. Kumar G, Kumar A, Patil A, Kumar B, Rastogi AK, Singh NK. Gender Differentiation by Articulated Pelvic Index: A Radiological Study Over the Population of Bihar. *Indian Internet Journal of Forensic Medicine and Toxicology*. 2020;18(1):41-5. <http://dx.doi.org/10.5958/0974-4487.2020.00008.5>
2. Madadin M, Siddique N, Waris A, Khan MA, Albarbari HS, Atreya A, et al. Research trends in forensic anthropology: A bibliometric analysis. *Journal of Forensic and Legal Medicine*. 2022;86:102305. <https://doi.org/10.1016/j.jflm.2022.102305>
3. Shepitko VY, Shepitko MV. The role of forensic science and forensic examination in international

- cooperation in the investigation of crimes. *Journal of the National Academy of Legal Sciences of Ukraine*. 2021;28(1):179-86.  
[http://dx.doi.org/10.37635/jnalsu.28\(1\).2021.179-186](http://dx.doi.org/10.37635/jnalsu.28(1).2021.179-186)
4. Clemente MA, La Tegola L, Mattera M, Guglielmi G. Forensic radiology: An update. *Journal of the Belgian Society of Radiology*. 2017;101(Suppl 2).  
<https://doi.org/10.5334%2Fjbr-btr.1420>
  5. AÇIKGÖZ AK, BOZKIR MG. The Importance of Morphometric Measurements of Adult Human Dry Hip Bone in Acetabular Reconstruction. *Journal of Contemporary Medicine*. 2022;12(5):685-91.  
<https://doi.org/10.16899/jcm.1134666>
  6. Viciano J. Sexual dimorphism from vertebrae: its potential use for sex estimation in an identified osteological sample. *Australian Journal of Forensic Sciences*. 2022;54(4):546-58.  
<http://dx.doi.org/10.1080/00450618.2020.1840629>
  7. Byers SN. *Introduction to forensic anthropology*: Routledge; 2016.  
<https://routledgetextbooks.com/textbooks/9781032255590/>
  8. Adhvaryu AV, Patel M, Gohil DV, Patel MM. A study of sexual dimorphism in Ischiopubic index of adult human hip bones. *Int J Anat Res*. 2019;7(2.3):6627-31. <https://dx.doi.org/10.16965/ijar.2019.190>
  9. Fukuta M, Kato C, Biwasaka H, Usui A, Horita T, Kanno S, et al. Sex estimation of the pelvis by deep learning of two-dimensional depth images generated from homologous models of three-dimensional computed tomography images. *Forensic Science International: Reports*. 2020;2:100129.  
<https://doi.org/10.1016/j.fsir.2020.100129>
  10. Kumar G, Kumar A, Patil A, Kumar B, Rastogi AK, Kumar P. Sex differentiation by ischio-pubic index: A radiological study over the population of Bihar. *Journal of Indian Academy of Forensic Medicine*. 2020;42(3):164-6. <http://dx.doi.org/10.5958/0974-0848.2020.00045.7>
  11. Haider A, Kamran S, Arif M, Raouf D. Role of ischiopubic index in sex determination on pelvis x-rays. *Journal of The Society of Obstetricians and Gynaecologists of Pakistan*. 2019;9(4):231-4.
  12. Curate F. The Estimation of Sex of Human Skeletal Remains in the Portuguese Identified Collections: History and Prospects. *Forensic Sciences*. 2022;2(1):272-86.
  13. Abdallah RS, El Sayed HR, Abdel Moawed DMN. Forensic assessment of sex using pelvic X-rays in Libyan population in Tripoli. *Zagazig Journal of Forensic Medicine*. 2021;19(1):91-101.
  14. Varzandeh M, Akhlaghi M, Farahani MV, Mousavi F, Jashni SK, Yousefinejad V. The diagnostic value of anthropometric characteristics of ilium for sex estimation using pelvic radiographs. *International Journal of Medical Toxicology and Forensic Medicine*. 2019;9(1):1-10.  
[https://doi.org/10.22037/ijmtfm.v9i1\(Winter\).22624](https://doi.org/10.22037/ijmtfm.v9i1(Winter).22624)
  15. Bubalo P, Baković M, Tkalčić M, Petrovečki V, Mayer D. Acetabular osteometric standards for sex estimation in contemporary Croatian population. *Croatian medical journal*. 2019;60(3):221-6.
  16. Ahmed S, Sreenivasan M. Sex Determination using the Ischiopubic Index in South Indian Population. *Indian Journal of Forensic Medicine & Toxicology*. 2021;15(2).  
<https://doi.org/10.37506/ijfmt.v15i2.14400>