Sex Determination using Radiographic Measurement of Pelvic Angles in Delta State University Teaching Hospital, Oghara, Nigeria

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Abstract

Background:
The pelvic bone is the most reliable sexually dimorphic bone in humans, and most accurate in determining age and sex.

Materials and Methods:
This descriptive cross-sectional study was conducted in the Radiology Department of Delta State University Teaching Hospital, Oghara, Nigeria. Pelvic radiographs of 175 males and 169 females, aged 25 to 50 years were used to measure angles in degrees. Data obtained was statistically analysed using GraphPad Prism. Basic descriptive statistics (mean, standard deviation and range) summarised data. Independent sample t-test, paired sample t-test, pearson's correlation and multiple logistic regression analysis were conducted with statistical significance pegged at p-value < 0.05.

Results:
There were significant sex differences in all pelvic angles. Right pubic ramus angle and left pubic ramus angle were significantly higher (p-value < 0.05) in males while subpubic angle, right X angle and left X angle were significantly higher (p-value < 0.05) in females. Significant side difference was observed in bilateral pelvic angles except for X angle in males. There was no association between the pelvic angles and age. Sex can be accurately determined applying multiple logistic regression models with subpubic angle and X angles serving as better sex predictors.

Conclusion:
Male pelvis has a greater pubic ramus angle than females, whereas female pelvis has greater subpubic and X angles than males. The subpubic angle and X angles revealed impressive accuracy levels in sex determination, exceeding eighty percent.

Keywords: Pelvis, sex, pubic ramus angle, subpubic angle, X angle.

Introduction

The pelvic bone is the most reliable sexually dimorphic bone in humans and most accurate in determining age and sex.[1,2] The pelvis is a useful bone in determining sex because apart from the general sex differences present in the bone, it has special features in females that make child bearing possible.[3,4]

Sex determination is very essential and a foremost step in the creation of a biological profile for human bones.[5,6] The methods used to determine sex broadly involve two categories: morphological and metric.[7]It is faster to identify physical features and morphological appearance of a bone; however, it is very subjective, requires an expert and may not be accurate.[8,9]Morphological methods for determining sex are therefore not reliable.[10] On the other hand, measurements are more precise and can accurately ascertain sex.[11,12]

Sex can be ascertained with a perfect accuracy of 100% when the complete human adult skeleton is present. However, in a situation like mass disasters where only portions of bones are recovered, it will be challenging to perfectly ascertain sex.[13] Radiographic methods can be employed to measure dimensions to deduce specific formulae which can be applied to estimate values for sex.[14] These measurements are the most common modern method for forensic investigation such as sex determination which is mostly studied using pelvis.[15]

This study aimed at determining sex using angles of pelvic radiographs at Delta State University Teaching Hospital (DELSUTH), Oghara.

Materials and Methods

This descriptive cross-sectional retrospective study of quantitative design was conducted in the Radiology Department of Delta State University Teaching Hospital (DELSUTH), Oghara in Delta State of Nigeria. The subjects were male and female patients aged 25 to 50 years who visited the Radiology Department of Delta State University Teaching Hospital (DELSUTH), Oghara for anterior-posterior pelvic x-rays from January, 2018 to December, 2022.

This study comprised all anterior-posterior pelvic radiographs that met the inclusion criteria. The purposive sampling technique was adopted for this study. The radiographs that were included in this study belong to patients aged 25 to 50 years because at 25 years all the bones of the pelvis must have fully ossified,[16] sex difference is best studied after puberty[17] and because the reduction of bone mass in Nigerian women commonly begins at 50 years before men.[18] The radiographs that were used also indicated best alignment at the inferior margin of the pubic bones at the pubic symphysis, this is because misalignment is best determined at the lower margin.[19] Pelvic radiographs whose bones are not clearly visible, indicated fractures, trauma, pathological disorders or deformities affecting the pelvic bone and/or proximal femur were excluded.

Method of data collection/measurements

The digital anterior-posterior pelvic x-ray radiographs stored in Picture Archiving and Communication System (PACS) were retrieved. The angular measurements were taken using digital protractor in degrees by one researcher to prevent inter-observer errors

Each parameter was measured twice and the average was taken to prevent intra-observer errors. The following pelvic angles were measured:

Subpubic Angle: The angle formed between two tangent lines drawn at the inferior border of the left and right pubic rami just below the pubic symphysis (Figure 1).

Pubic Rami Angle: The angle formed between two tangent lines drawn at the superior border of pubic superior ramus and inferior border of pubic inferior ramus bilaterally (Figure 1).

X Angle: The angle formed between two lines drawn at inferior border of ischial tuberosity to the superior point of acetabulum and the inferior border of pubic inferior rami bilaterally (Figure 1).

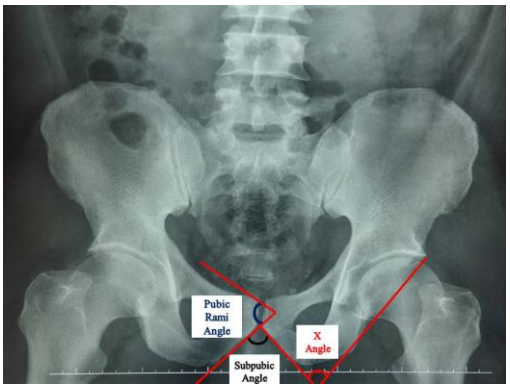

Figure 1: Measurement of subpubic angle, pubic rami angle and X angle

Ethical Consideration: Approval for this research was obtained from the Research and Ethics Committee of the Faculty of Basic Medical Sciences, Delta State University, Abraka (RBC/FBMC/DELSU/23/307) and also from the Research and Ethics Committee of Delta State University Teaching Hospital, Oghara, Delta State (HREC/PAN/2023/007/0536).

Data Analysis: The data obtained was statistically analysed using GraphPad Prism version 8.4.3 software. Independent samples t-test was used to test the mean difference between males and females. Paired samples t-test was used to test the mean difference between paired samples. Pearson's correlation test was used to determine the relationship between the pelvic angles and age for males and females. Multiple logistic regression analysis was used to determine the model for sex determination and accuracy of the pelvic parameters for correct sex prediction. A p-value < 0.05 was considered statistically significant.

Results

A total of three hundred and forty-four (344) anterior-posterior pelvic radiographs were utilized in this study. 50.9% (175) of the study subjects were males while 49.1% (169) were females (Figure 2). The age of the study subjects ranged from 25 to 50 years with an average of 37.49±7.11 years. The average age of females was 37.89±7.13 years while males had an average age of 37.11±7.09 years.

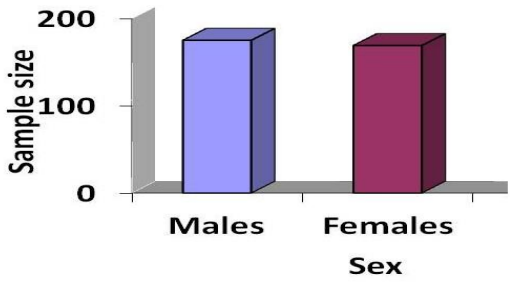

Figure 2: Composition of study sample

Table 1: Independent samples t-test of the pelvic angles

Parameter	Males	Females	t	p-value
Subpubic angle (°)	100.30±15.52	136.9±14.57	22.540	0.001*
Right pubic rami angle (°)	72.78±10.14	63.05±12.53	7.927	0.001*
Left pubic rami angle (°)	71.47±10.05	61.91±12.05	8.008	0.001*
Right X angle (°)	75.99±8.30	91.49±8.56	17.06	0.001*
Left X angle (°)	76.34±8.80	92.39±9.32	16.430	0.001*

°=degrees, *=significant, t=t-test value

Table 2 shows the paired samples t-test of pelvic angles measured bilaterally. There was significant side differences (p-value<0.05) in both males and females except for X angle (p-value=0.217) in males.

Table 2: Paired samples t-test of pelvic angles

Parameter		Males			Females		
	Side	Mean	t	p-value	Mean	t	p-value
Pubic rami angle (°)	Right	72.78±10.14	3.338	0.001*	63.05±12.53	2.971	0.003*
	Left	71.47±10.05			61.91±12.05		
X angle(°)	Right	75.99±8.30	1.240	0.217	91.49±8.56	2.887	0.004*
	Left	76.34±8.80			92.39±9.32		

°=degrees,*=significant, t= t-test value and df=degree of freedom

Table 3 shows the Pearson's correlation test was used to determine the relationship between the pelvic angles and age for males and females. The pelvic angles lacked significant association with the age in both sexes.

Table 3: Correlation between the pelvic angles and age for males and females

Parameter	Males		Females	
	R	p-value	R	p-value
Subpubic angle	-0.032	0.670	0.007	0.926
Right pubic rami angle	0.009	0.910	-0.067	0.385
Left pubic rami angle	0.036	0.634	-0.086	0.269
Right X angle	-0.048	0.532	-0.046	0.550
Left X angle	-0.043	0.575	-0.065	0.403

R=correlation coefficient

Table 4 indicates the multiple logistic regression analysis. The multiple logistic regression model is Sex=β0 + β1*x where β0 is coefficient for males, β1 is coefficient for females and x is the measured value of pelvic parameter. If the value obtained is less than 0.5, the sex predicted is male but if the value is equal or greater than 0.5, the sex predicted is female. All pelvic angles are statistically significant predictors of sex (p-value<0.05). The subpubic angle and X angles were more accurate (above 80%) for sex determination.

Table 4: Multiple logistic regression analysis for pelvic angles

Parameter	Sex	Coefficient (β)	SE	Odds Ratio	Accuracy (%)	p-value
Subpubic angle	Males	-16.670	1.736	5.758	86.86	
	Females	-16.670	0.014	1.150	91.12	0.001*
Right pubic rami angle	Males	4.917	0.736	136.600	69.71	
	Females	-0.073	0.011	0.930	57.99	0.001*
Left pubic rami angle	Males	5.004	0.742	149.000	70.29	
	Females	-0.075	0.011	0.927	61.54	0.001*
Right X angle	Males	-17.170	1.756	3.493	80.00	
	Females	0.204	0.021	1.227	85.80	0.001*
Left X angle	Males	-16.250	1.686	8.726	80.57	
	Females	0.193	0.020	1.212	82.84	0.001*

SE=standard error of estimate, *=significant, %=percentage

Discussion

The subpubic angle was significantly wider in females, as previously noted in India among the Punjab by Kanika *et al.*, [20] Iran by Akhlaghi *et al*,[21] Sudan by Badawi *et al.*,[22] and Mohammed and

Awad,[23] Malaysian population by Ali *et al.* [24] and among the Nepalese population of Italy by Kayastha *et al.*[25] and Pandit *et al.* [26]. Also, studies conducted in Nigeria by Oladipo *et al.*[27] among Ijaws and Igbos as well as Anyanwu *et al.*[28] among Igbos supported the same. They believed that a wider subpubic angle is critical for accommodating childbirth, a key factor in the sexual dimorphism of the pelvis.

The mean value of subpubic angle in the study sample was significantly wider than those of Kanika *et al.*[20] and Ali *et al.* [29] On the other hand, the subpubic angle mean was not significantly lesser than those of Kayastha *et al.* [25] and Pandit *et al.*[26] Measuring tools such as goniometer as well as steel bars and protractor which previous studies employed was replaced by a digital protractor in present study. These differences in measuring tools in addition to different study population were likely to be responsible for the varying mean values of subpubic angle.

The right and left pubic rami angles were wider in males than females as indicated in previous study.[30] These findings are a contributing factor to the mechanical demands on male pelvis and are not suited for parturition. Furthermore, the X angles, both right and left, were significantly greater in females than males. The same was seen in the study of Memarian *et al.*[30] This finding supported the notion that female pelvic structures are adapted for childbirth.[30]

The pubic rami angles were also larger on the right side in both males and females, which may be linked to differences in gait or leg dominance.[30] Interestingly, while no significant difference was found in the X angle of males, females exhibited a larger left X angle than right X angle which was statistically significant, potentially reflecting differences in pelvic tilt or flexibility required for childbirth.[30]

The mean pubic rami angle in this study was significantly greater than the mean reported by Memarian *et al.* [30] conducted in Iran. The mean X angle of this study was however significantly lesser than that of Memarian *et al.*[24] Environmental factors such as climate, nutrition, occupation as well as varying ethnicity, race, genes, culture and physical activity accounted for this difference.

The lack of association between pelvic angles and age in males and females suggested that pelvic angles remain relatively stable across the studied age range of 25 to 50 years after complete pelvis ossification had occurred.

The subpubic angle showed highest discriminatory power in distinguishing between male pelvis and female pelvis. Specifically, the subpubic angle had an accuracy of 86.86% for males and 91.12% for females, which corroborates findings by Igbigbi and Msamati [3] who reported subpubic angle accuracy as 94.7% for females and 95.5% for males and also findings by Mahmoud *et al.*[31] and Setiawati *et al.*[32]

These results suggest that the subpubic angle remains a reliable marker for sex estimation across various populations. The pubic rami angle and X angle are also excellent variables in distinguishing between sexes.

Conclusion

This study has demonstrated significant sexual dimorphism in various pelvic angles. The findings suggest that the male pelvis has a greater pubic ramus angle than females, whereas female pelvis has greater subpubic and X angles than males. Overall, this research provides critical insights that various pelvic parameters can serve as reliable predictors of sex. The subpubic angle and X angles revealed impressive accuracy levels in sex determination, exceeding eighty percent.

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