Original Article

Forensic Assessment of Sex Using Pelvic Bone X-rays in Libyan Population in Tripoli

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ABSTRACT

Background: Estimation of sex represents one of the most important aspects of analysis in forensic anthropology. Selection of appropriate methods depends on what skeletal elements are present and what general age is represented. The pelvis is possibly the most accurate bone in the human body for age and sex determination, with the accuracy being 95% when completed. **Aim:** This study aimed to test the accuracy of sex identification using digital pelvic radiography in a sample of Libyan Population in Tripoli. **Subjects and methods:** This cross-section study was carried out at the Orthopedic Traumatic Center of Tripoli Hospital, Libya during the period study from January to March 2020. It included 156 persons (15-25 years) in two groups; Group I which include 78 Males. Group II which included 78 females). All subjects will be subjected to antero-posterior pelvis X-rays to determine sex estimation by: the height of ilium, interacetabular distance, acetabular diameter, pelvic breadth and pelvic inlet breadth. **Results:** In comparison between male and female in different measured parameters, there was a statistical significance increase in the height of ilium and acetabular diameter in males and in inter-acetabular distance and breadth of pelvic inlet among females; but no statistical significance difference found between males and females in greatest breadth of pelvis. **Conclusion:** The pelvis bone could be used for sex determinations with the maximum percentage of 68% sex estimation accuracy. It may be a reliable tool in estimation of forensic sex estimation.

Keywords: Forensic, Age assessment, Pelvic bone, X-ray.

I. Introduction:

Gender identification is an important step in the identification process of mass disaster victims (Byers, 2017).

Age and sex identification is vital in the forensic investigations of many civil, criminal, and immigration cases (Norouzi et al., 2019; Wittschieber et al., 2013).

Sex determination from bony remains is usually a difficult task. In the forensic field, bodies are commonly torn apart, leaving only body parts or bony remains for the identification process. In these cases, sex determination becomes a problematic task (Iscan and Steyn, 2013).

The most accurate bone used to determine the age and sex of humans has been reported to be the pelvis, with an accuracy of up to 95%. The composite, the subpubic angle, and ventral arc accuracy in gender determination were 98%, according to estimates from Schmeling et al. (2016).

According to the morphology, compared with the male pelvis, the female pelvis is wider and shallower, with a wide, short, less curved sacrum and little projection of the sacral promontory (Hamunen, 2014; Warrener et al., 2015).

These morphological differences between the pelvic bones of both sexes make the hip bone one of the most important bones to determine sex with high accuracy in humans (Huseynov et al., 2016).

The use of hip bones in forensic death investigations is common (Hartnett, 2010). For age estimation, the union of epiphysis mainly at the iliac crest has long been used (Martins et al., 2012).

Pelvic bone X-rays have also been used in preceding studies for sex determination. Sex determination from bone is reported to be population-specific (Varzandeh et al., 2019).

This research aimed to estimate the accuracy of gender identification using pelvic radiography in the Libyan population.

II. Subjects and method:

The study was performed at the Tripoli Hospital in the Orthopedic Traumatic Center. It was a cross-sectional study done during the period from January to March 2020. Ethical approval of the study was obtained from the Institutional Review Board (IRB), Faculty of Medicine, Zagazig University, Egypt.

II.1 Inclusion and exclusion criteria:

Inclusion criteria were determined to include subjects from 15–25 years of age, both males and females. On the other

hand, the study excluded patients with bone deformities, subjects with ages < 15 years and > 25 years, congenital or acquired bony problems, or trauma to the pelvis.

II.2 Methodology:

The subjects in the study were 156 individuals, divided into two groups: Group I involved 78 males, and Group II involved 78 females. Pelvic bone X-rays were then performed by a digital X-ray machine. Anteroposterior views were obtained from the subjects in a supine position, and the focus film distance was 100cm.

Five measurements were obtained (Varzandeh et al., 2019):

- The ilium height (the maximum distance between the center of the acetabulum and the uppermost point of the iliac crest).
- Interacetabular distance (the distance between left and right midpoints of the acetabular fossa).
- The diameter of the acetabulum (the maximum vertical diameter of the acetabulum).
- The breadth of the pelvis (the maximum distance between the two most lateral portions of the iliac crests).
- The breadth of the pelvic inlet (the maximum distance between the two most lateral portions of the pelvic inlet).

II.3 Statistical Analysis:

The results were statistically analyzed by version 25.0 of SPSS program (Statistical Package for Social Science). The significance level for the student-t test was then computed. P value is considered significant if <0.05.

III. Results:

The study showed that the ilium height and the diameter of the acetabulum were significantly higher in males than females (Figure 1), and the same was true for the interacetabular distance (Figure 2).

The breadth of the pelvic inlet was significantly higher in females than males (Figure 3). The study showed no significant difference in the greatest breadth of pelvis between both sexes (Table 1) (Figure 4) .

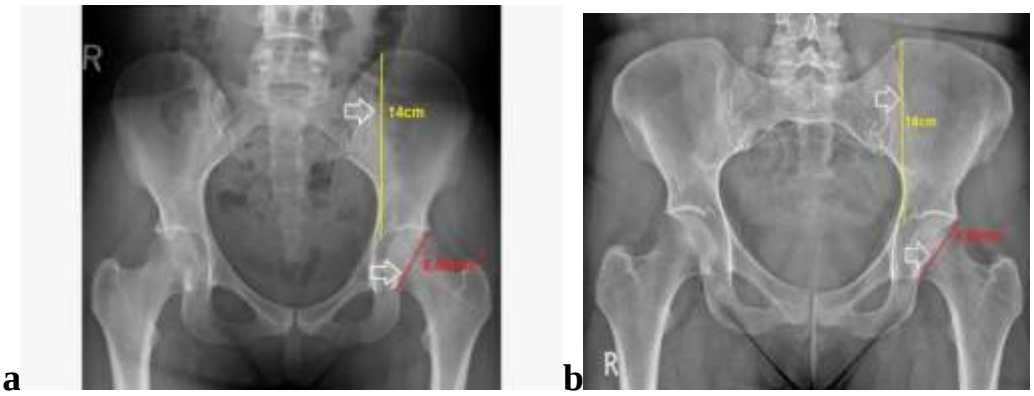


Figure 1: Pelvic bone X-ray (anteroposterior view) showing the ilium height (yellow line) and the diameter of the acetabulum (red line), with a greater increase in the male pelvis (a) than the female pelvis (b).

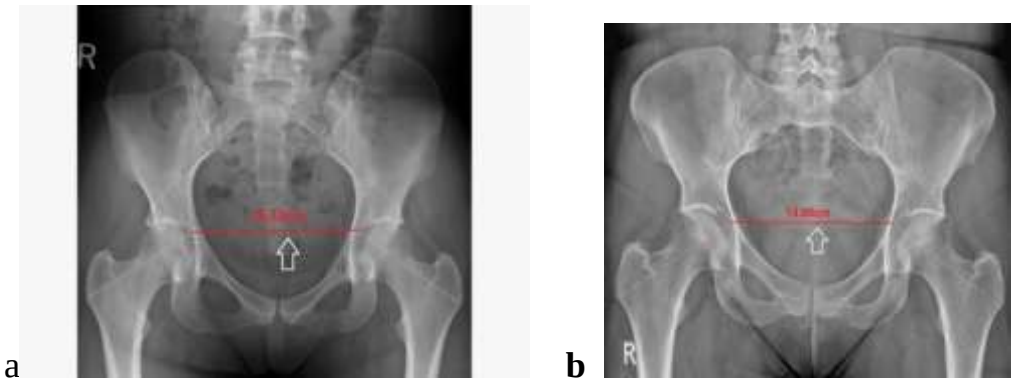


Figure 2: Pelvic bone X-ray (anteroposterior view) showing a greater increase of the interacetabular distance (red line) in the male pelvis (a) than the female pelvis (b).

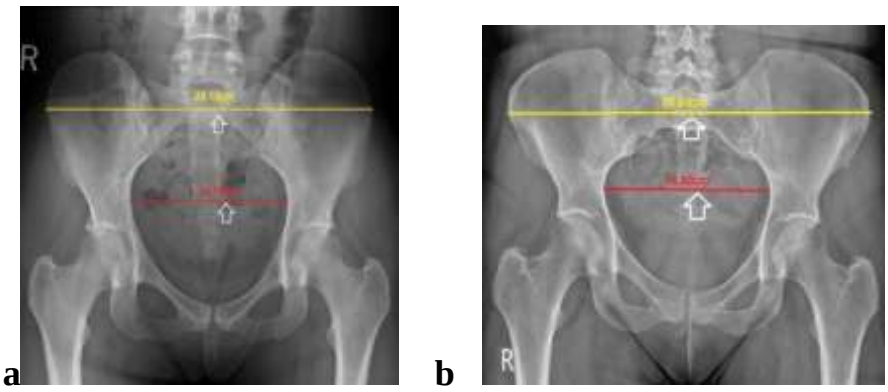


Figure 3: Pelvic bone X-ray (anteroposterior view) showing a greater increase of the pelvic inlet breadth (red line) in the female pelvis (a) than the male pelvis (b).

Table (1): Comparison between Group I (males) and Group II (females) in the various pelvic measures by using student t test:

Variable	Male (n=78) Group I	Female (n=78) Group II	T	P value
The height of ilium:				
Mean ± SD	15.17 ± 1.24	13.97 ± 0.96	**6.79**	**<0.001****
Range	13 – 17.7	12 – 15.4		
Inter-acetabular distance:				
Mean ± SD	14.15 ± 1.21	15.25 ± 1.53	**4.97**	**<0.001****
Range	11.5 – 16.5	12 – 18.2		
Acetabular diameter:				
Mean ± SD	6.55 ± 0.51	6.04 ± 0.55	**6.06**	**<0.001****
Range	5.6 – 7.5	5.1 – 7.2		
Greatest breadth of pelvis:				
Mean ± SD	32.94 ± 3.36	32.34 ± 2.38	1.29	0.20 NS
Range	28 - 38	28.5 – 36.5		
Breadth of pelvic inlet:				
Mean ± SD	14.09 ± 1.18	15.16 ± 1.46	**5.03**	**<0.001****
Range	11.5 – 16.5	12.3 – 17.6		

SD: Standard deviation t: Student t test **: (P<0.001): Highly Significant

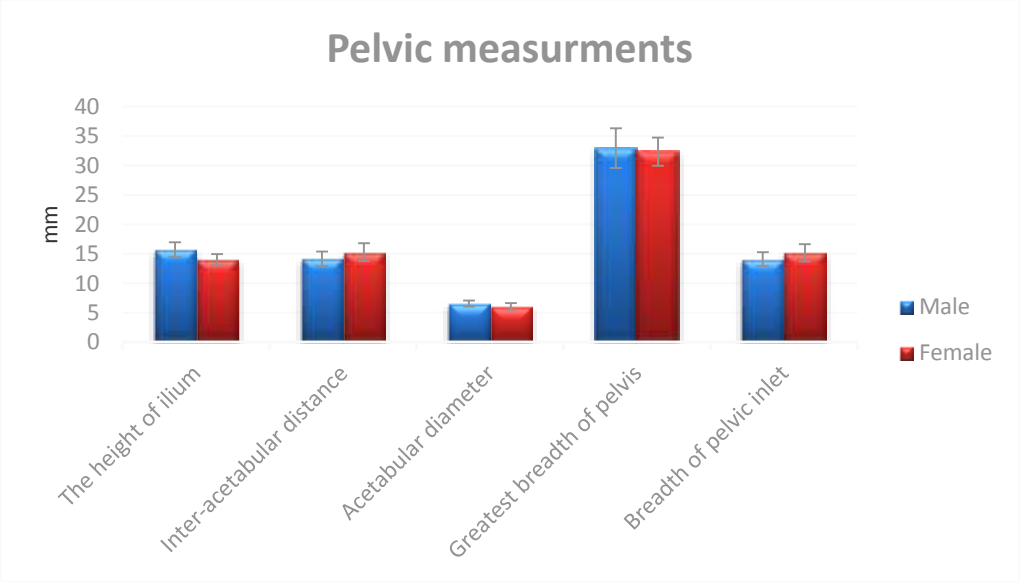


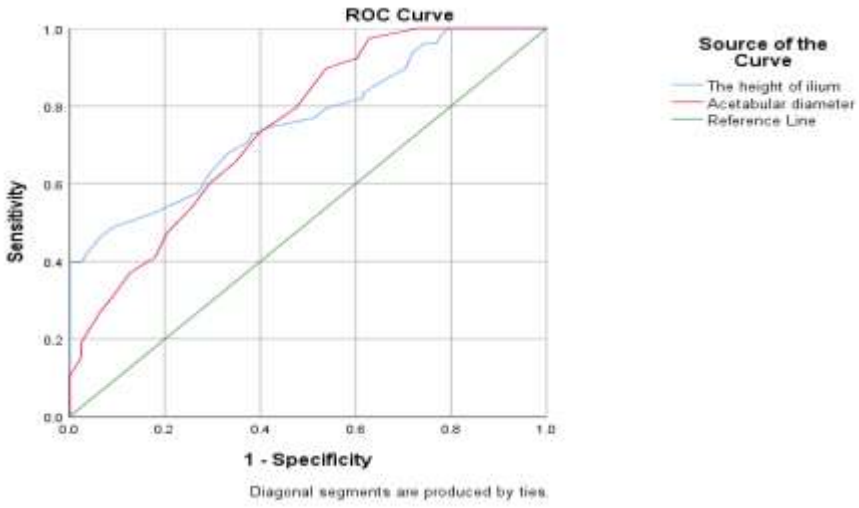
Figure 4: Bar chart showing comparison between Group I (males) and Group II (females) in the various pelvic measures.

The accuracy of the pelvic measures in sex identification was determined. The accuracy of the ilium height in the determination of male gender at cut off more than 14.55 mm was 68.6% and that of inter-acetabular distance at cut off less than 15.05 mm was 64.1% while cut off more than 6.15 mm was 66.7% and that of the pelvic inlet breadth at cut off less than 14.95 mm was 60.3% (Table 2) (Figure 5).

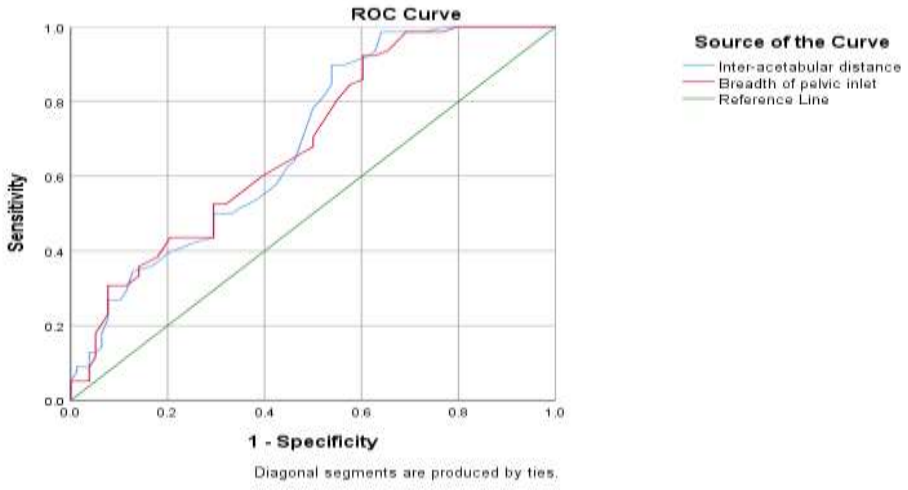
Table (2): Accuracy of pelvic measures in gender identification in Group I (males) and Group II (females) using the Roc curve result:

Variable	Cut off	AUC (95% CI)	Sens.	Spec.	PPV	NPV	Accuracy	P value
The ilium height	**>14.55**	0.76 0.68-0.83	70.5	**66.7**	**67.9**	**69.3**	**68.6**	**<0.001 ****
Inter-acetabular distance	**<15.05**	0.69 0.61-0.77	78.2	**50**	**61**	**69.6**	**64.1**	**<0.001 ****
The diameter of the acetabulum	**>6.15**	0.75 0.67-0.82	73.1	**60.3**	**64.8**	**69.1**	**66.7**	**<0.001 ****
Pelvic inlet breadth	**<14.95**	0.68 0.60-0.77	70.5	**50**	**58.5**	**62.9**	**60.3**	**<0.001 ****

AUC: Area under curve, CI: Confidence interval, Sens.: Sensitivity, Spec.: Specificity, PPV: Positive predicted value, NPV: Negative predicted value, (P<0.01): Highly significant.



a



b

Figure 5: Roc curve for accuracy of pelvic measures in gender identification in Group I (males) and Group II (females). **a**: height of the ilium and acetabular diameter; **b**: inter-acetabular distance and the pelvic inlet breadth.

IV. Discussion:

Forensic sex and gender determination are considered important forensic investigations that are commonly requested by the court to solve many criminal and civil cases (Schmeling et al., 2016). Many bones in the human body can be used to determine gender, like the pelvis, skull, and sternum (Christensen et al., 2014) .

The variation in hormonal pattern between both sexes at the time of growth causes a difference in the morphology of the pelvis, making the pelvis one of the most accurate bones to determine gender (Badyaev, 2002; Huseynov et al., 2016) .

Since the determination of sex from bone is population-specific, this study aimed to estimate the accuracy of gender identification using pelvic radiography in the Libyan population. The study used pelvic X-rays from 156 individuals grouped equally into males and females with the age from 15-25 years. The ilium height, the distance of interacetabular area, the diameter of the acetabulum, the pelvis breadth, and the pelvic inlet breadth were measured in both groups.

In the present research, there was a statistically significant increase in the ilium height and the diameter of the acetabulum among males and in the distance of the inter-acetabular area and the breadth of the pelvic inlet

among females, but regarding the maximum breadth of the pelvis, there was no significant difference between both sexes.

Many other studies also used the pelvis for gender determination using various modalities, including measuring the ilium height and the diameter of the acetabulum and concluded their significance in different populations (Patriquin et al., 2005; Steyn& İşcan, 2008; Sitek et al., 2012). Parmara et al. (2013) used some acetabular measurements like anterior acetabular ridges, diameter of the acetabulum, and depth of the acetabulum in gender identification.

Going hand in hand with our results, Varzandeh et al. (2019) also measured the ilium height, the distance of the interacetabular area, the diameter of the acetabulum, the maximum pelvic breadth, and the pelvic inlet breadth in 180 individuals of the Iranian population. They found that the radiographic imaging of pelvic bones is effective in determining gender.

This research found that the diameter of the acetabulum increased significantly more in males, while the distance of the interacetabular area increased significantly more in females. These results were like the results of preceding studies (Patriquin et al., 2005; Sitek et al., 2012; Parmara, 2013).

In the current research, the mean height of the ilium was greater in males than females. On the contrary, it was lower in males than females in other studies performed on Polish people, Greek people, and South Africans (Patriquin et al., 2005; Steyn& İşcan, 2008; Sitek et al., 2012).

In the current research, the pelvic inlet breadth was significantly greater in females. This result was like the results of other studies performed on Iranian, Greek, Polish, and New Zealand people (Steyn& İşcan, 2008; Mullaji, 2010; Sitek et al., 2012).

There was no significant difference in the maximum pelvic breadth between both sexes in the current study, which could be due to belonging to the same population or the small sample size of the study.

By measuring the sensitivity, specificity, and accuracy of sex determination, the accuracy of the ilium height in determining male gender was 68.6%, and that of the

distance of the inter-acetabular area was 64.1%, while the accuracy of the diameter of the acetabulum was estimated to be 66.7% and that of the pelvic inlet breadth was 60.3%. Varzandeh et al. (2019) found that the estimated accuracies of sex determination were 77%, 72%, 71%, and 67% for the ilium height, the diameter of the acetabulum, the breadth of the pelvic inlet, and the distance of the inter-acetabular area, respectively.

V. Conclusion:

Forensic radiology is a reliable tool in sex determination. Pelvic bone measurements can be used in gender identification with an accuracy of 68%.

VI. Conflict of interest:

No conflict of interest is stated by the authors.

VII. References:

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التقدير الشرعي للجنس باستخدام الأشعة السينية على عظام الحوض للسكان الليبيين في طرابلس

المقدمة: يعتبر تقدير جنس الأشخاص من الأدلة الهامة التي تساعد في عملية الاستعراف الطبى الشرعي لتحديد هوية الضحايا في الجرائم والحوادث، و يعتمد اختيار طرق التحديد على عمر الضحية والأجزاء المتاحة من الهيكل العظمي، ويعد الحوض من أكثر العظام دقة في جسم الإنسان لتحديد العمر والجنس بنسبة تصل إلى 95 ٪ في العظمة المكتملة.

الهدف من العمل: تهدف هذه الدراسة إلى تحديد درجة الدقة في التعرف على جنس الأشخاص باستخدام الأشعة السينية على الحوض في عينة من السكان الليبيين في طرابلس.

طريقة الدراسة: أجريت هذه الدراسة في مدينة طرابلس بمركز جراحة العظام بليبيا في الفترة من يناير إلى مارس 2020، بلغ حجم العينة في هذه الدراسة 156شخص من (15-25 عام)، تم تحديد جميع المشمولين في الدراسة وتقسيمهم بالتساوي بين مجموعتين: المجموعة الأولى: وشملت 78 شخص من الذكور، والمجموعة الثانية: وشملت 78 شخص من الإناث. خضع جميع المشمولين في الدراسة إلى التصوير الأمامي بالأشعة السينية على الحوض لتحديد الجنس بقياس: ارتفاع التعظم الحرقفي، والمسافة بين الحلقات، وقطر الحلقات، واتساع الحوض، واتساع مدخل الحوض (الحد الأقصى للمسافة بين الجزأين الجانبيين لمدخل الحوض).

النتائج: وجدت الدراسة بعد مقارنة القياسات المستخدمة بين الذكور والإناث أن قياس ارتفاع التعظم الحرقفي والمسافة بين الحلقات يزيد في الذكور أكثر من االناث، بينما يزيد قياس قطر الحلقات واتساع مدخل الحوض في الإناث أكثر من الذكور، ولا يوجد اختلاف كبيرفي قياس اتساع الحوض بين الذكور والإناث.

الاستنتاج:

- يعتبرعظم الحوض جيد لتحديد الجنس مع نسبة قصوى تصل الي ٪86 دقة تقدير الجنس .

-تعتبر الأشعة السينية جيدة وفعالة وللتقدير الشرعي للجنس.