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 included 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:

Estimation of sex of the victim or remains is important guide that help in the process of identification (Byers, 2017).

In living, it is important to determine the true age and sex of individuals in radiology and forensic medicine (Norouzi et al., 2019). The legal sex of adolescents and young people is an important issue in civil, criminal, and immigration law (Wittschieber et al., 2013).

In fact, it is not always easy to determine sex by skeletal remains. It is a common scenario in forensic medicine that corps is dismembered before identification. Sometimes, only skeletal remnants or parts of the body are available. In these situations, sex estimation becomes more difficult and problematic (Iscan and Steyn, 2013**).**

The pelvis is possibly the most accurate bone in the human body for age and sex determination, with the accuracy being 95% when completed. In addition, it is estimated that the accuracy of gender identification from the subpubic angle, ventral arc, and composite is approximately 98% (Schmeling et al., 2016).

The female sacrum is wider, shorter, and less curved, and the sacral promontory projects less into the pelvic cavity, thus giving the female pelvic inlet (pelvic brim) a more rounded or oval shape compared to males (Warrener et al., 2015). The lesser pelvic cavity of females is also wider and shallower thanthe narrower, deeper, and tapering lesser pelvis of males (Hamunen, 2014**).**

Because of the obvious differences between female and male hip bones, this is the one bone of the body that allows for the most accurate sex determination **(**Huseynov et al., 2016**).**

The study of the pelvis in cadavers has long been used for forensic purposes (Hartnett, 2010). In the living, the analysis of the process of ossification and fusion of pelvic bones has mainly focused on the iliac crest (Martins et al., 2012).

There are many previous studies that used the pelvic bone X-rays to determine sex (Varzandeh et al., 2019)**.**

Estimation of sex from bone is population specific, so this study aimed to test the accuracy of sex identification using digital pelvic radiography in a sample of Libyan Population in Tripoli.

II. Subjects and methods:

A cross-section study was carried out at the Orthopedic Traumatic Center of Tripoli Hospital during the period study from January to March 2020. Approval of the study was obtained from the Department of Forensic Medicine and Toxicology and

Institutional Review Board (IRB), Faculty of Medicine, Zagazig University, Egypt.

II.1 Inclusion and exclusion criteria:

Subjects included in the study with age from 15 to 25 years of both sex (males and females). While, the study excluded patients with any bone deformities, age < 15 years and > 25 years, patients with known congenital or acquired skeletal diseases or pelvic trauma and subjects with a history of developmental bone disorders.

II.2Subjects and method:

The study includes 156 persons in two groups; Group I which included 78 males and Group II which included 78 females. Antero-posterior view of pelvic bone using digital X-ray machine was obtained and computed. The radiograohs were obtained while patient was supine with focus film distance equals 100cm.

Five landmarks were measured:

- The height of ilium (the maximum distance between midpoint of the acetabulum and the upper point of the iliac crest).

- Inter-acetabular distance (the distance between left and right middle points of the acetabular fossa).

- Acetabular diameter (the maximum vertical diameter of the acetabulum).

- Pelvis breadth (the maximum distance between the two most lateral parts of the iliac crests).

- Pelvic inlet breadth (the maximum distance between the two most lateral parts of the pelvic inlet).

II.3 Statistical Analyses:

The collected data were computerized and statistically analyzed using SPSS program (Statistical Package for Social Science) version 25.0. The significance Level for student-t test was done. The threshold of significance is fixed at 5% level (P-value), P value of <0.05 indicates significant results.

III. Results:

There was a statistical significance increase in the height of ilium and acetabular diameter in males **(Figure 1),** and in inter-acetabular distance **(Figure 2)** and breadth of pelvic inlet **(Figure 3)** among females. There was no statistical significance difference found between males and females in measurement of greatest breadth of pelvis (**Table 1**) **(Figure 4).**

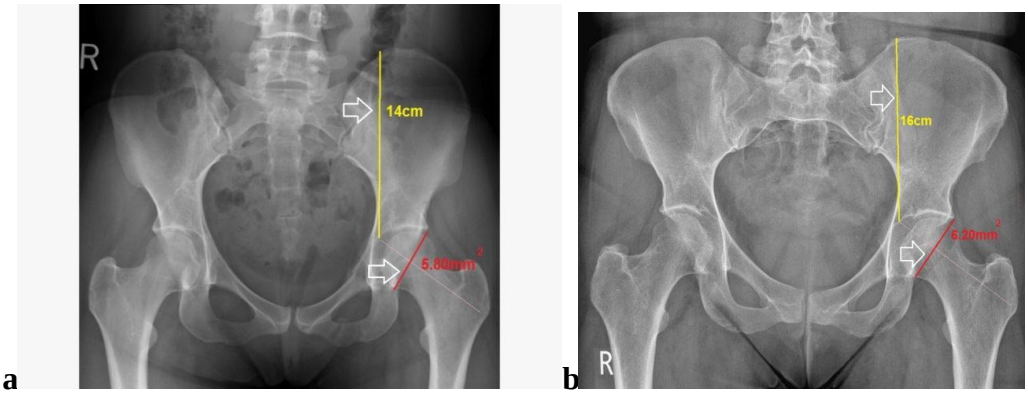

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Figure 1: Anteroposterior view of pelvic bone X-ray of female (a) and male (b) showing more increase in maximum height of the ilium (yellow line) and acetabular diameter (red line) in male pelvis.

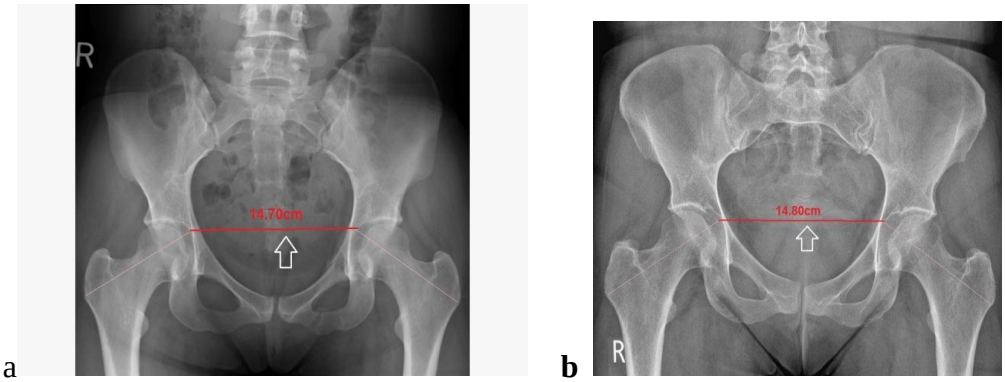

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Figure 2: Anteroposterior view of pelvic bone X-ray of male (a) and female (b) showing more increase of inter-acetabular distance in female pelvis. Arrow: Inter-acetabular distance (the distance between the left and right middle points of the acetabular opening).

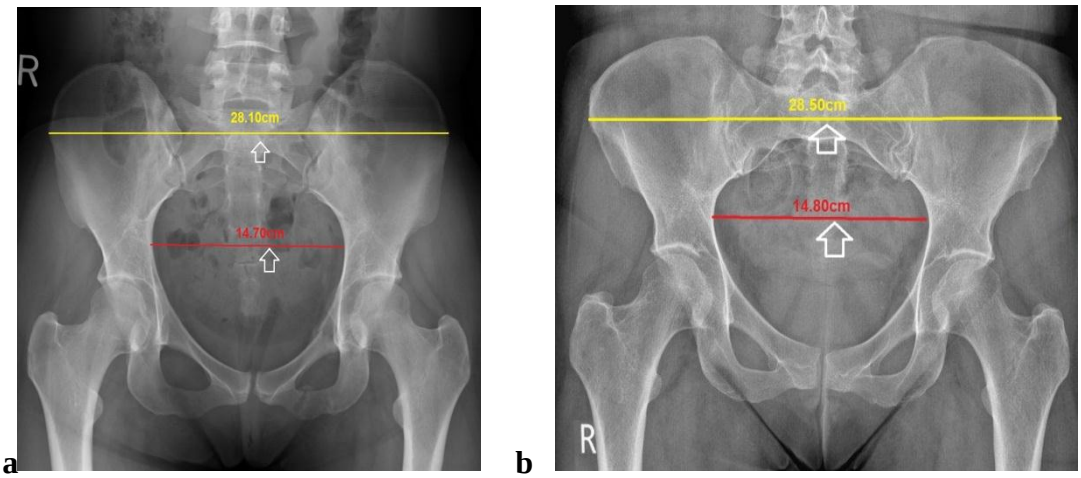

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Figure 3: Anteroposterior view of pelvic bone X-ray of male (a) and female (b) showing more increase in pelvic inlet breadth (red line) in female pelvis.

Table (1): Comparison between male and female in different measured parameters in Group I (males) and Group II (females) by using student t test:

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

SD: Standard deviation, t: Student t test **: Highly Significant (P<0.001); NS: non significant

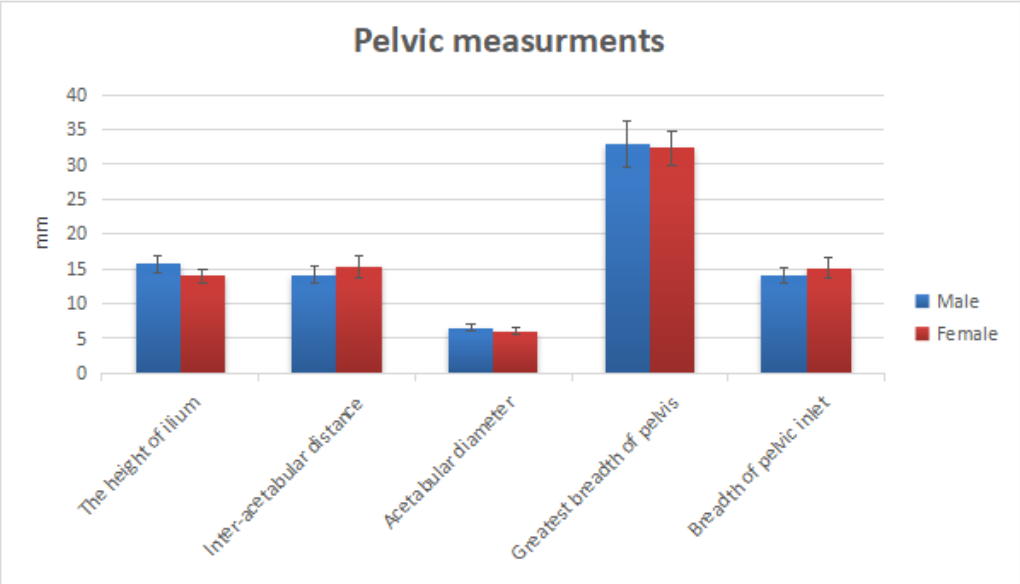

Figure 4: Bar chart showing comparison between males and females in different measured parameters (the height of the ilium, inter-acetabular distance, acetabular diameter, greatest breadth of pelvis and breadth of the pelvic inlet).

In this study, the accuracy of the measured parameters was estimated. The accuracy of the height of ilium in determination of male sex 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 the accuracy of acetabular diameter at cut off more than 6.15 mm was 66.7% and that of breadth of pelvic inlet at cut off less than 14.95 mm was 60.3% (**Table 2**) **(Figure 5).**

Table (2): Accuracy of pelvic measurements in sex determination in both Group I (males) & Group II (females) by using Roc curve interpretation:

Variable	Cut off	AUC (95% CI)	Sens.	Spec.	PPV	NPV	Accuracy	P value
The height of ilium:	**>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 ****
Acetabular diameter:	**>6.15**	0.75 0.67-0.82	73.1	**60.3**	**64.8**	**69.1**	**66.7**	**<0.001 ****
Breadth of pelvic inlet:	**<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, **: Highly Significant (P<0.01)

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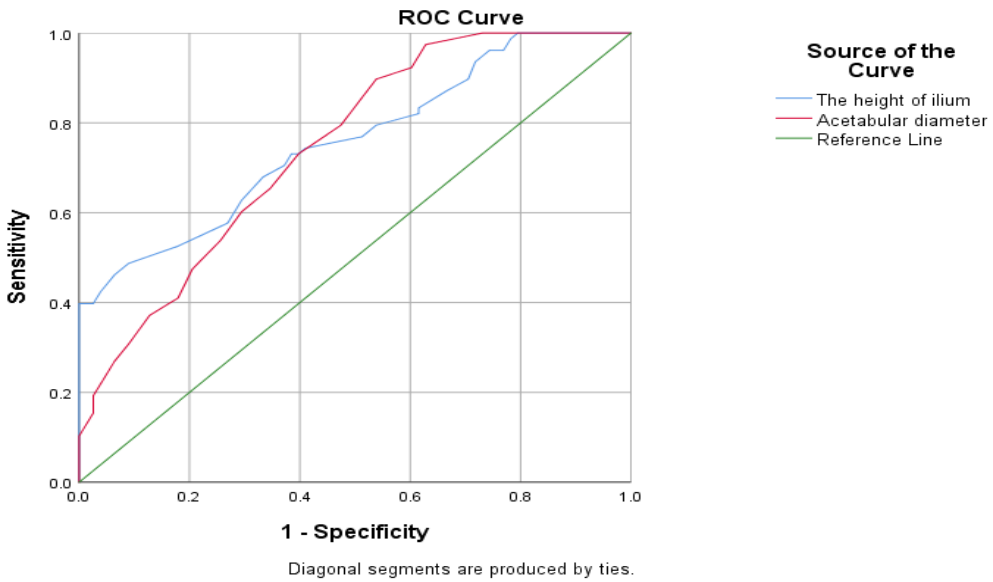

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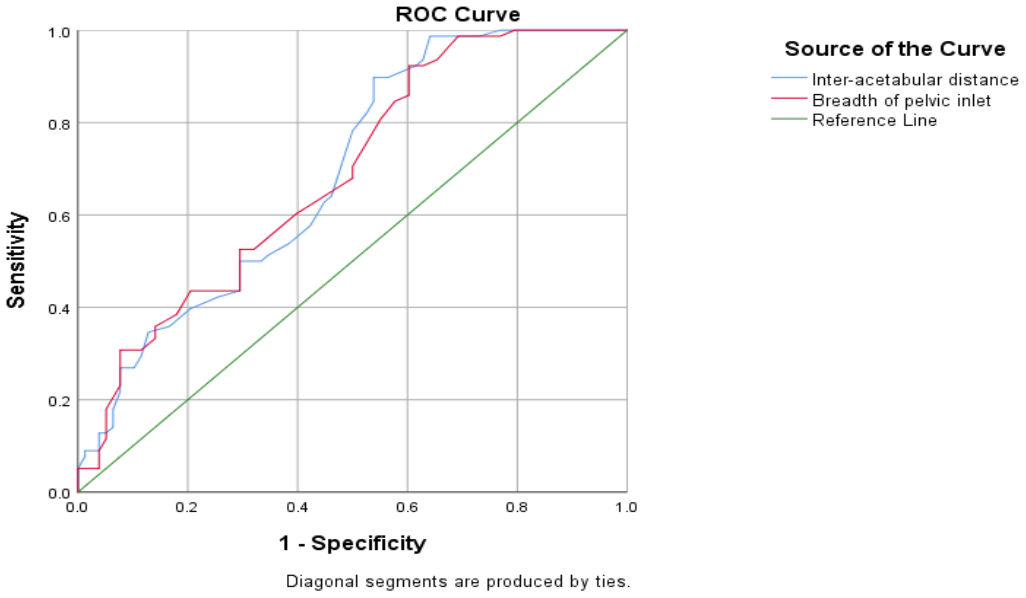

Figure 5: Roc curve for accuracy of pelvic measurements in sex determination among males and females in the studied group (I and II). a: height of the ilium and acetabular diameter; b: inter-acetabular distance and breadth of the pelvic inlet

IV. Discussion:

Forensic sex and age estimation is requested by courts and other government authorities so that all legal procedures to which an individual's sex and age is relevant can be properly followed (Schmeling et al., 2016). Different parts of the body are utilized in the determination of sex, such as the pelvis, long bones with an epiphysis and a metaphysis in skeletons (Christensen et al., 2014). The pelvis is possibly the most accurate bone in the human body for age and sex determination. The pelvic differences between males and females may be a result of hormonal influence on bone growth. Sex-specific hormones during growth, such as testosterone and estrogen, have been hypothesized to influence pelvic morphology (Badyaev, 2002**;** Huseynov et al., 2016**).**

Estimation of sex from bone is population specific, so this study aimed to test the accuracy of sex identification using digital pelvic radiography in a sample of Libyan Population in Tripoli. The study determined the forensic sex using pelvic X-rays on a 156 individuals (50% males and 50% females) ranged from 15-25 years with measurement of the height of ilium, inter-acetablular distance, acetabular diameter,

greatest breadth of pelvis, and breadth of pelvic inlet between both sexes.

The result of this study found that 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 regarding the greatest breadth of pelvis; there was no statistical significance difference found between males and females.

Multiple studies have been conducted on the pelvis for sex estimation using different methods, including measuring the height of ilium and acetabular diameter and concluded that, there was significant differences exist between Indian, European and African anthropometry (Patriquin et al., 2005; Steyn& İşcan, 2008; Sitek et al., 2012). Parmara et al. (2013) reported that anterior acetabular ridges, diameter of the acetabulum and depth of acetabulum are important in sex determination. Varzandeh et al. (2019) research coincided with this research results. He measured the height of ilium, inter-acetabular distance, acetabular diameter, the greatest breadth of the pelvis, breadth of pelvic inlet in radiography of 180 pelvic bones (90 males and 90 females). They concluded that when pelvic bones are available, standard radiographic images along with other findings can be helpful in predicting the sex.

Like most other studies, this research found that the acetabular diameter was significantly higher in male and the inter-acetabular distance was higher in female (Patriquin et al., 2005; Sitek et al., 2012; Parmara, 2013).

In present study the mean ilium height was higher in male than female, yet it was less in male than female in previous studies conducted on Polish people, Greek people and South Africans (Patriquin et al., 2005; Steyn& İşcan, 2008; Sitek et al., 2012).

In the present study, we found that the breadth of the pelvic inlet was significantly higher in females. This result was similar to findings by other studies that studied on Iranian, Greek, Polish, and New Zealand people, respectively. The mean breadth of the pelvic inlet was different between these studies which could be due to the methodological differences (Steyn& İşcan, 2008; Mullaji, 2010; Sitek et al., 2012).

The greatest breadth of the pelvis was not different between males and females in the present study, which could be due to the similarity between the two sexes in this population or a small sample size which could not highlight this difference.

Using ROC curves, sensitivity, specificity, and accuracy for sex estimation, the height of ilium, inter-acetabular distance, pelvic inlet breadth and acetabular diameter in

determined remarking points were calculated. The accuracy of the height of ilium in determination of male sex was 68.6% and that of inter-acetabular distance was 64.1% while the accuracy of acetabular diameter was 66.7% and that of breadth of pelvic inlet was 60.3%. Varzandeh et al. (2019) demonstrated that, the accuracies of sex estimation were 77%, 72%, 71% and 67% for the height of ilium, acetabular diameter, breadth of pelvic inlet and inter-acetabular distance respectively**.**

V. Conclusion:

The pelvis bone is good for sex determinations with the maximum percentage of 68% for sex estimation accuracy. X-ray examination may be a good and reliable tool in estimation of sex in forensic field.

VI. Conflicts of interest

There is no conflict of interest to declare.

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

المقدمة: يعد تقدير جنس الضحية من الأدلة المهمة التي تساعد في عملية تحديد الهوية في مجال الطب الشرعي لتحديد هوية الضحايا في الجرائم والحوادث، و يعتمد اختيار طرق التحديد على عمر الضحية والأجزاء المتاحة من الهيكل العظمي، ويعد الحوض هو أكثر العظام دقة في جسم الإنسان لتحديد العمر والجنس بنسبة تصل إلى ٩٥ ٪ في العظمة المكتملة.

الهدف من العمل: تهدف هذه الدراسة إلى اختبار دقة تحديد الجنس الشرعي باستخدام الأشعة السينية على الحوض في عينة من السكان الليبيين في طرابلس.

طريقة الدراسة: أجريت هذه الدراسة في مركز جراحة العظام في مدينة طرابلس بليبيا في الفترة من يناير إلى مارس ٢٠٢٠، بلغ حجم العينة في هذه الدراسة ١٥٦شخص من (١٥-٢٥ عام)، تم تحديد جميع المشمولين في الدراسة وتقسيمهم بالتساوي بين مجموعتين: المجموعة الأولى: وشملت ٧٨ شخص من الذكور، والمجموعة الثانية: وشملت ٧٨ 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 القساسات المستخدمة بين الذكور والإناث أن قياس ارتفاع التعظم الحرقفي والمسافة بين الحلقات يزيد في الذكور أكثر من الاناث، 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 ٨٦٪ دقة تقدير الجنس .
- تعتبر الاشعة السينية جيدة وفعالة وللتقدير الشرعي للجنس.