



The Influence of Population Variability on Pelvic Sexual Dimorphism: A Case Study from the Parthian Cemetery (247 BCE to 224 AD), Liyarsangbon in Guilan, Iran.

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Abstract

A population-specific approach to skeletal analysis is critical due to the impacts of environmental and cultural factors on human variation. This study analysed sex determination in 77 individuals, discovered from the Liyar-Sang-Bon cemetery in Guilan, Iran (2016–2018), using both metric and non-metric innominate bone assessments. Its primary aim was to evaluate the applicability of global standards and identify factors shaping anatomical variation in this population. Initial analyses applied global sex determination methods, followed by statistical comparisons (t-tests) to identify reliable indicators within the pelvis, including the sacrum and Os coxae. The results reveal significant sexual dimorphism in certain pelvic regions, although not all indicators met the statistical threshold ($P < 0.05$). These findings highlight the limitations of universal standards, emphasising the need for population-specific data. They also demonstrated that results may vary when using with larger or more diverse samples. The study underscores the challenges of pelvic-based sex estimation due to biological and population diversity. By comparing traditional and modern methods, it advocates for localised methodologies and contributes invaluable insights into human biodiversity. Future research that integrates broader skeletal evidence with larger sample sizes is essential for refining techniques and enhancing accuracy in both forensic and bioarchaeological applications.

Keywords: Local Sex Determination, Metric and Nonmetric Measurements, Statistical Analysis, Sexual Dimorphism, Liyarsangbon, Guilan.

Article Type: Research Article

Introduction

Sex determination from skeletal remains is vital in bioarchaeology and forensic anthropology, particularly through the examination of the pelvis, which displays distinct sexual dimorphism. Environmental and cultural factors significantly influence the anatomy of specific populations (Boucher 1957; Kelly and Reynolds 1947). The pelvic differences associated with reproduction create structural distinctions between males and females that can even be observed in juveniles. The accuracy of these determinations improves post-puberty, as secondary sexual traits develop (Choi and Trotter 1970). However, juvenile sex estimation is

challenging due to variations in age and maturation (Schutkowski 1993; Vlak *et al.* 2008). Additionally, fragile pubic bones can limit analysis; other bones or DNA may provide alternative insights (Huseynov *et al.* 2016; Schmidt-Schultz and Schultz 2004). Interpreting pelvic morphology requires standardised methods that take into account population-specific variations and environmental influences. Evolutionary and social theories can also elucidate biological and cultural impacts on skeletal variation (Franklin *et al.* 2007; Choi and Trotter 1970).

This study examines methodologies and challenges in sex determination from the pelvis, comparing traditional morphological approaches with



modern analytical techniques. Focusing on the indigenous remains from the Liyarsangbon cemetery in Amlash, Guilan, it evaluates whether standard sex determination methods are universally applicable or if they require region-specific adaptations. The research highlights the significance of the pelvis, known for its significant sexual dimorphism, in understanding human biodiversity, reconstructing patterns of sexual dimorphism across populations, and improving forensic practices. By addressing methodological issues, the study aims to enhance the accuracy and relevance of pelvic-based sex estimation for both archaeological and forensic applications.

Area of Study

The ancient site of Liyar-Sang-Bon, located at coordinates $36^{\circ}55'50.85''$ N and $50^{\circ}02'09.86''$ E, is a vast archaeological area located between the villages of Shirchak, Shieh, and Marbu (Figure. 1). The site's elevation ranges from 1,311 to 1,751 metres above sea level, covering an approximate area of 54 hectares.

The dataset analysed in this research originates from three excavation seasons that took place from 2016 to 2018. A comprehensive excavation at the

Liyarsangbon archaeological site (Figure. 1) led to the discovery of 77 skeletons, conducted by an expedition from the Cultural Heritage and Tourism Organisation of Guilan Province. This archaeological team was directed by Vali Jahani, and the remains were meticulously recovered, cleaned, and recorded in collaboration with the Biological Anthropology Laboratory at the University of Guilan (Eghdami *et al.* 2023).

Methodology

Bone samples were transported to the osteology section of the Biological Anthropology Laboratory at the Research Institute of Guilan Studies (RIGS), University of Guilan, under the supervision of a biological anthropologist from the university (the author). The analysis focused on pelvic landmarks for gender determination, using both qualitative and quantitative methods based on global biological anthropology standards (Figures. 2,3,4 and 6). Measurements were taken using standard anthropometric callipers, targeting innominate bone samples divided into sacrum and coccyx (Table. 1) and coxal or os coxae (Ubelaker and Volk 2002: 16–21). Variables were assessed using T-tests, with statistical analyses examining their significance (Tables. 1–3).

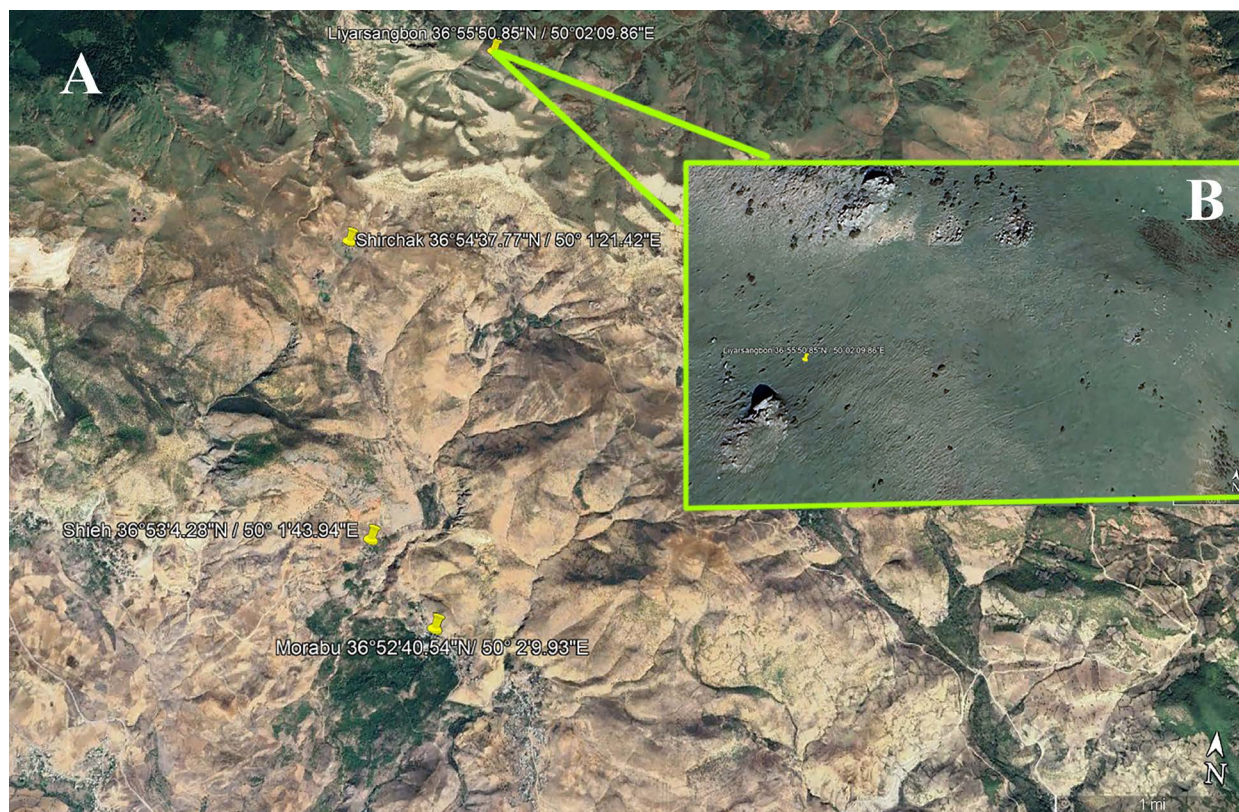


Figure. 1: (A) An overview of the Liyarsangbon archaeological site, including the geographical coordinates and surrounding areas. (B) A detailed view of the excavated site based on aerial mapping. Source: Google Earth (08/04/2025), modified by Author.

The skeletal remains originated from the Liyarsangbon site. Pelvic features used for sex determination included metrics such as anterior height, ventral arc height, iliac length, and acetabular dimensions, among others (Flander 1978: 21-22; Haas *et al.* 1994: 17-20; Martin 1928: 73). Key landmarks for visual assessment included the greater sciatic notch (Mittler *et al.* 1992), ventral arc ridge, subpubic concavity (Sutherland and Suchey, 1991; Ubelaker and Volk, 2002), and metrics based on the Phenice method (Phenice 1969: Section 18.4.4). Visual classifications were categorised into absolute male (M+), male (M), unknown (Un), female (F), and absolute female (F+) across five groups (Klales *et al.* 2012). Data were statistically analysed using SPSS 26, utilising descriptive statistics (frequencies and mean variance), t-tests for single samples, and Pearson correlation to test hypotheses. The Mann-Whitney U test was employed to assess non-parametric and qualitative variables. This non-parametric method, also known as the Wilcoxon Rank-Sum test, compares two independent samples to determine if they likely come from the same population or if one tends to have larger or smaller values than the other (Mann and Whitney 1947: 51-58). Crosstabulation was conducted to display the quantity of samples measured at each level, aligning with the sample size to facilitate comparison.

Results and Discussions

It's crucial to distinguish between the biological notion of sex and the social construct of gender (Grauer 1995: 41). The pelvis is particularly effective for sex estimation, especially in adults. However, there are limitations when it comes to juveniles. Employing both visual and metric analyses of pelvic morphology can improve accuracy, especially when additional skeletal data, contextual clues, and molecular methods can be integrated when feasible (Buikstra and Scott 2009).

The Phenice method, which examines sexually dimorphic traits in the pubic region, achieves a high accuracy rate (96-100%) for adult pelvic bones, although this may vary across different populations. The accuracy of this method is enhanced through visual examination and the expertise of osteologists (Phenice 1969; Ubelaker and Volk 2002: 49-54).

Statistical analyses are used to compare male and female variable means. Tables 1-3 present significance (t-values), mean differences, standard deviations, and ranges of these variables, with those having p-values below 0.05 ($p < 0.05$) being considered significant. These analyses aid descriptive and inferential analyses.

Sacrum

Sacral measurements (Figure.2) are crucial in forensic anthropology and bioarchaeology for determining the sex of skeletal remains. The sacrum is a triangular bone at the spine's base and exhibits morphological differences between males and females, due to variations in pelvic anatomy influenced by biological and functional factors like childbirth (Işcan and Shihai 1995: 78; Kranioti and Michalodimitrakis 2009; Singh and Potturi 1978). Sex determination involves analysing features such as Maximum Anterior/Height Length, Maximum Anterior Breadth, Ventral Arc, Dorsal Height, Anterosuperior Breadth, Middle Breadth, Auricular Surface Height, Auricular Surface Breadth, and Transverse Diameter/Base (Figure.2).

The maximum anterior height of the sacrum refers to the longest vertical measurement along its anterior surface, taken from the sacral promontory to the lowest anterior point (Figure. 2). This measurement is vital for both sex determination studies and clinical assessments (Standring and Borley 2008). Male sacra are generally taller, narrower, and more curved than female sacra, which are adapted for childbirth with broader and less curved structures (Schönburg *et al.* 2020: 8). Females typically exhibit a reduced anterior sacral height and wider pelvic dimensions to support parturition (Tague 1992: 16-17). A t-test (-0.17, p-value = 0.868) showed no significant difference in maximum anterior/height length between males (mean 102.5) and females (mean 103.8) (Table. 1). The slight difference in means may reflect population-specific findings, highlighting the need for further research with larger or more diverse samples. The Maximum Anterior Breadth of the sacrum is the widest horizontal measurement of the sacral base, usually taken at its upper region where it articulates with the fifth lumbar vertebra (Figure.2). This metric is widely used in anthropological, anatomical, and osteological studies to examine pelvic morphology, determine biological sex, and analyse evolutionary traits in vertebrates (Standring and Borley 2008: 388). Females generally display a broader, shorter, and more curved sacrum, resulting in a greater maximum anterior breadth compared to males (White *et al.* 2011: 219-240). A t-value of 1.965 at a significance level of .059 indicates no statistically significant difference between males and females. Males show a higher mean maximum anterior breadth (114.3) compared to females (109.5). Although not statistically significant in this case, these differences may be specific to the studied population. Larger or



Figure. 2: Sacral measurements highlighting various parts of the sacrum can be utilised for sex determination. These parts consist of maximum anterior /height length, maximum anterior breadth; ventral height arc, dorsal height, anterosuperior breadth, middle breadth, auricular surface height, auricular surface breadth, transverse diameter/base
(Photography and Marking by Author).

more diverse samples may yield different findings. The ventral arc of the sacrum refers to an anatomical structure on the anterior surface of the sacrum (Figure.2). It is measured as the surface distance between the ventral midline point of S-1, or the sacral promontory, and the inferoventral midline point of the S-5 vertebral body (Martin 1928: 998). The male sacrum is generally narrower, more curved, and elongated, resulting in a more prominent ventral height arc compared to females. This shape supports a taller, more vertically aligned pelvis. The t-value indicates “No,” showing no statistically significant difference between males and females (Table. 1). However, the mean ventral arc ridge score is higher in females (102.3) than in males (101.5), suggesting that further increases in sample size or studies of different populations may potentially af-

fect the outcomes. Sacral dorsal height refers to the vertical measurement along the back surface of the sacrum (Figure.2). It serves as a key anthropometric parameter in forensic science and anatomy for determining biological sex. Male and female skeletons show distinct differences due to sexual dimorphism, making sacral dorsal height, among other skeletal features, an important indicator for sex assessment. Typically, females have a wider but shorter sacrum, which aids experts in forming evaluations when combined with other skeletal measurements (Bass 2005: 122). The t-value of 0.286 corresponds to a p-value of 0.781, indicating no statistically significant difference between males and females (Table. 1). However, the average sacral dorsal height is slightly higher in males (108.4) than in females (106.5). This suggests that increasing the sample size or

modifying the study population could influence the results. In human osteology, the anterosuperior margin of the sacrum refers to the anterior superior border of the sacral bone. The transverse distance is measured between the highest superoventral points of the auricular margins (Figure.2). This region is critical for sex determination due to the distinct morphological differences between males and females (Haas *et al.* 1994; Martin, 1928: 1006). The t-value of -1.338, with a p-value of .192, indicates no statistically significant difference between sexes (Table .1). Nonetheless, the mean breadth is higher in females (107.8) than in males (105.2), suggesting that changes in sample size or population characteristics could influence the results.

The sacral auricular surface height is a metric used in forensic anthropology for sex determination. Males generally have larger and more pronounced auricular surfaces than females, whose structures are smaller and less robust (Haas *et al.*, 1994: 429; Martin, 1928: 1000). The t-value of 1.652 and a p-value of 0.116 indicate no statistically significant difference between sexes (Table. 1). However, males show a higher average sacral dorsal height (65.7)

than females (59.2), suggesting that an expanded sample size or altered study population might affect the findings.

The maximum dorsoventral dimension of the auricular surface, as identified by Martin (1928), aligns with trends in auricular surface breadth (Figure.2). Males have a mean measurement of 48.8, while females show a higher mean of 51.8. With a t-value of -0.701 and a p-value of 0.492, the results indicate no statistically significant difference between males and females (Table. 1).

Two variables, middle breadth and transverse diameter/base (Figure.2), show statistically significant differences between males and females. Middle breadth, defined as the transverse distance between the lowest points of the auricular margins (Martin 1928), has a p-value of .02 and a t-value of 2.673, with males averaging 91.6 compared to 71.6 in females (Table. 1). Similarly, the transverse diameter/base, with a mean of 54.4 for males and 50.2 for females, has a p-value of .029. These differences align with distinct global metric landmarks observed within the studied samples and population.

Table. 1: Differences in sexual dimorphism based on metric variables in the sacral region.

	Variable	Sex	N	Mean	Sd.	Min	Max	Sig. (p)	t	Yes/No
	Sacrum	Max Anterior /Height length	M	9	102.5	16.57	73.7	131.5	.868	-.17**
F			5	103.8	8.22	98.3	117.7			
Max Anterior Breadth		M	17	114.3	5.66	103	130.9	.059	1.965	No
		F	13	109.5	7.74	95.2	121.2			
Ventral Height Arc		M	8	101.5	17.83	73.7	130.4	.929	-.091	No
		F	5	102.3	9.81	91.6	117.7			
Dorsal Height		M	8	108.4	13.83	92	128.6	.781	.286	No
		F	5	106.5	7.43	102	119.5			
Anterosuperior Breadth		M	18	105.2	5.2	95.6	115	.192	-1.338	No
		F	11	107.8	4.9	99.3	114.1			
Middle Breadth		M	10	91.6	5.33	80.5	96.8	.02	2.673	Yes
		F	4	71.6	23.52	36.4	85.8			
Auricular Surface Height		M	13	65.7	7.52	52.7	82.1	.116	1.652	No
		F	7	59.2	10	46	75			
Auricular Surface Breadth		M	13	48.8	7.34	32.3	60.1	.492	-.701	No
		F	7	51.8	11.7	42.4	75.3			
Transverse Diameter/Base		M	21	54.4	6.22	38.6	68.4	.029	2.276	Yes
		F	19	50.2	5.17	42.3	59.7			

Os coxal

Generally, the female pelvis is wider than the male pelvis, an adaptation that provides a larger birth canal to support childbirth. This difference plays a key role in sexual differentiation (Fischer and Mitteroecker 2017: 699; Huseynov *et al.* 2016: 5230).

To assess demographic variations and compare them with global landmarks, measurements were taken, including os coxae height, superior iliac breadth, iliac length, pubic length, acetabulosymphyseal length, ischial length, acetabular height, obturator foramen dimensions, sciatic notch depth, spino-sciatic and spino-auricular lengths, cotylo-sciatic breadth, and acetabulum vertical diameter (Figure.3). Calipers ensured precise averages from both sides for analysis.

found no significant difference between male (mean 207.2) and female (mean 197.1) measurements (Table. 2), indicating potential influences from sample size or demographics, despite the higher male mean (Figure.4).

Superior iliac breadth, or os coxae breadth (Figure.3), measures the distance between the anterior and posterior superior iliac spines (Haas *et al.* 1994: 432; Martin, 1928: 1001). Females typically have greater breadth than males (Moore *et al.* 2013). The analysis showed a t-value of 1.153 and a p-value of 0.262, indicating no statistically significant difference (Table. 2). Males had a higher mean score of 155.6, while females scored 148.8, suggesting a possible impact from sample size or demographics (Figure.4).

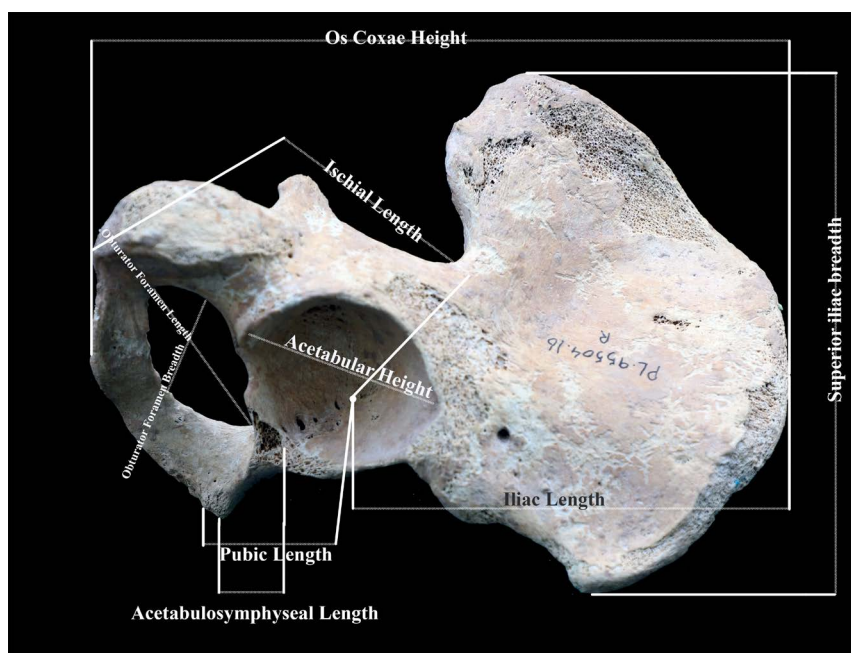


Figure. 3: Measurements of the os coxae, including height, iliac and pubic lengths, acetabulosymphyseal and ischial lengths, and dimensions of the obturator foramen. It also highlights the sciatic notch depth and acetabulum diameter (Photography and Marking by Author).

The subsequent variables, characterised by the specified statistical properties, indicate a lack of statistical significance (Table. 2).

The study of os coxae height (Figure.3) reveals that males typically have a greater measurement from the iliac crest to the ischiopubic ramus, attributed to their larger size and stronger skeletal features (Buikstra 1994: 81; Krogman and İşcan 1986: 551). A t-test (t-value = 1.347, p-value = 0.192)

Iliac Length (Figure.3) measures the distance from the superior edge of the acetabular notch, closest to the centre of the triradiate suture, to the farthest point on the iliac crest (Martin 1928: 1002). Sexual differences are linked to evolutionary adaptations, such as childbirth demands in females and structural support in males (Standing 2021: 401). The statistical results (t-value = 1.115, p-value = 0.273) show no significant sex-based difference (Table. 2). The

male mean score (131.4) is higher than the female mean score (126.2), possibly due to sample size or demographic variations (Figure.4).

Pubic Length (Figure.3) is defined as the distance from the superior edge of the acetabular notch near the triradiate suture to the farthest point on the pubic body (Haas *et al.* 1994: 431; Martin, 1928: 1002). Males typically have a shorter pubic length than females (Moore *et al.* 2013; Standing, 2021: 399). Statistical analysis (t-value = 0.300, p-value = 0.767) revealed no significant differences between sexes (Table. 2). Males recorded a slightly higher mean (73) than females (72.1), potentially reflecting the effects of sample size or demographic factors (Figure.4).

Acetabulosymphyseal Length (Figure.3) measures the distance from the lunate surface near the pubic symphysis to the highest point on the pubic symphysis (McCown 1939: 75). Males generally exhibit longer measurements due to their more robust pelvises (Krogman and İşcan, 1986; Tague, 1992). Statistical analysis (t-value = 0.374, p-value = 0.711) showed no significant difference between sexes (Table. 2). However, males had a marginally higher mean (21) compared to females (10), which could be attributed to sample size or demographic factors (Figure.4).

Acetabular height, measured from the lunate surface edge beneath the anterior inferior iliac spine to the furthest point on the lunate surface (Martin

Table. 2: The degree of disparity between men and women varies across different metrics, with some showing no significance while others highlight notable differences in current populations. **P<0.05

	Variable	Sex	N	Mean	Sd.	Min	Max	Sig. (p)	t	Yes/No
	OS Coxae	Os Coxae Height	M	20	207.2	13.14	177	233.5	.192**	1.347
F			4	197.1	16.65	179	213.35			
Superior Iliac/ Breadth		M	15	155.6	15.71	106	178.05	.262	1.153	No
		F	8	148.8	7	139	159			
Iliac Length		M	24	131.4	13.61	79.3	147.95	.273	1.115	No
		F	10	126.2	8.72	117	141.05			
Pubic Length		M	20	73	8.1	57	82	.767	.3	No
		F	11	72.1	6.01	60.6	82			
Acetabulo-Symphyseal Length		M	21	54.8	6.38	46	66.9	.711	.374	No
		F	10	53.9	5.21	47.85	64.8			
Ischial Length		M	20	93.6	12.87	66.15	117.1	.020	2.562	Yes
		F	7	82.9	7.92	74	98.2			
Acetabular Height		M	28	52.3	3.25	40	58	.281	1.091	No
		F	19	50.6	7.26	43.2	77			
Obturator Foramen Length		M	21	52.2	3.77	45.35	58.8	.062	1.940	No
		F	12	49.4	4.42	44	57.5			
Obturator Foramen Breadth		M	22	33.8	5.46	27.4	55.8	.725	-.355	No
		F	11	34.5	4	30.7	44.1			
Sciatic Notch Depth/ Height		M	18	39.9	8.3	23	61.8	.015	-2.584	Yes
		F	13	47.2	6.81	36.9	58.9			
Spino-Sciatic Length	M	27	71.8	5.48	61	82.2	.001	3.412	Yes	
	F	22	65.2	7.95	44	76.6				
Spinoauricular Length	M	27	74.2	4.63	66	83.7	.612	-.511	No	
	F	21	74.9	4	68.4	81				
Cotylo-Sciatic Breadth	M	27	35.8	3.5	31.3	44.8	.021	2.398	Yes	
	F	20	33.5	3	25	38.1				
Vertical Acetabular Diameter	M	28	56.7	7.78	19.3	64.9	.089	1.740	No	
	F	20	53.3	4.44	45.8	60.2				

1928: 1032), is generally higher in males than females (Lim et al., 2022). However, no statistically significant difference was found between males (mean = 52.3) and females (mean = 50.6) (t -value = 1.091, p -value = .281), suggesting that sample size or population variations may explain these results (Table. 2).

The length of the obturator foramen, measured from the obturator groove centre to its furthest lower edge (Martin 1928: 1033), is typically larger and more oval in males, while smaller and more triangular or irregular in females (Standring, 2021: 400). Although males had a higher mean (52.2) than females (49.4), a t -test showed no statistically significant difference (t -value = 1.940, p -value = .062), pointing again to sample size or demographic variability (Figure.4).

Obturator foramen breadth, defined as its maximum width at a right angle to its length (Martin, 1928), is generally larger and oval-shaped in males and smaller and often triangular in females (Gray et al., 1999: 1062; Krogman and İşcan, 1986: 557). In this case, females had a slightly higher mean score (34.5) than males (33.8), but a t -test revealed no significant difference between groups (t -value = -.355, p -value = .725), likely reflecting sample or population differences rather than true sex-based variation (Figure.4).

The spinoauricular length, measured between specific pelvic landmarks ((Figure.5), is used to

analyse pelvic morphology. Males typically exhibit a narrower, taller pelvis, resulting in a shorter spinoauricular length, whereas females have a broader, more horizontal pelvis, leading to a slightly longer spinoauricular length (Gray et al. 1999: 1055). Despite close mean scores for females (74.9) and males (74.2), no statistically significant difference was observed (t -value = -.511, p -value = .612). However, the unequal medians suggest that sample size and population may influence these results ((Figure.4).

The vertical acetabular diameter (height of the acetabulum) is the distance from the nearest point on the lunate surface to the highest point on the pubic symphysis (Figure.5) (McCown 1939). Differences in pelvic anatomy result in a generally larger vertical acetabular diameter, facilitating a wider pelvic inlet and outlet (Singh and Potturi, 1978; Standring 2021: 334). While males had a slightly higher mean score (56.7) than females (53.3), the difference was not statistically significant (t -value = 1.740, p -value = .089). This small variation may stem from sample size or demographic factors rather than innate anatomical differences ((Figure.4).

Four variables display significant differences between males and females, as outlined in Table 2. Ischial Length (Figure.3) is measured from the acetabular notch near the triradiate suture to the ischium endpoint, showing a t -value of 2.562 and a p -value of .02, with means of 93.6 (male) and 82.9 (female) (Haas et al. 1994: 437; Martin, 1928:

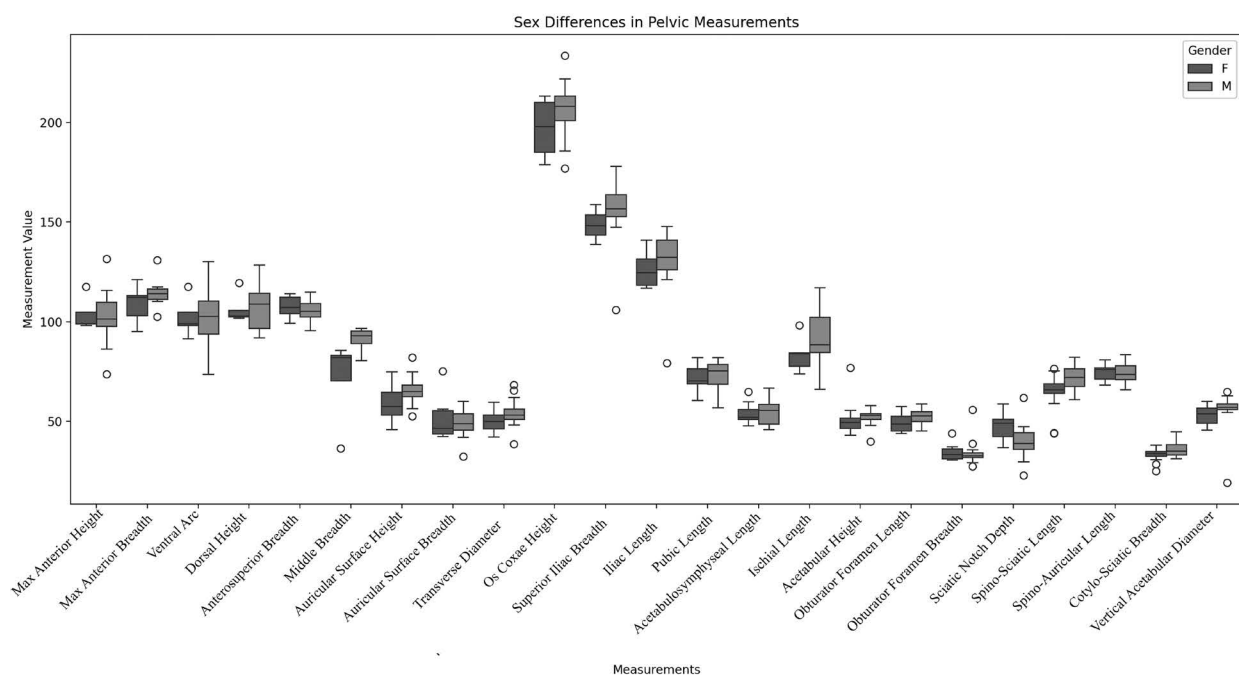


Figure. 4: : The boxplot effectively demonstrates the variations in pelvic metric measurements between male and female subjects.

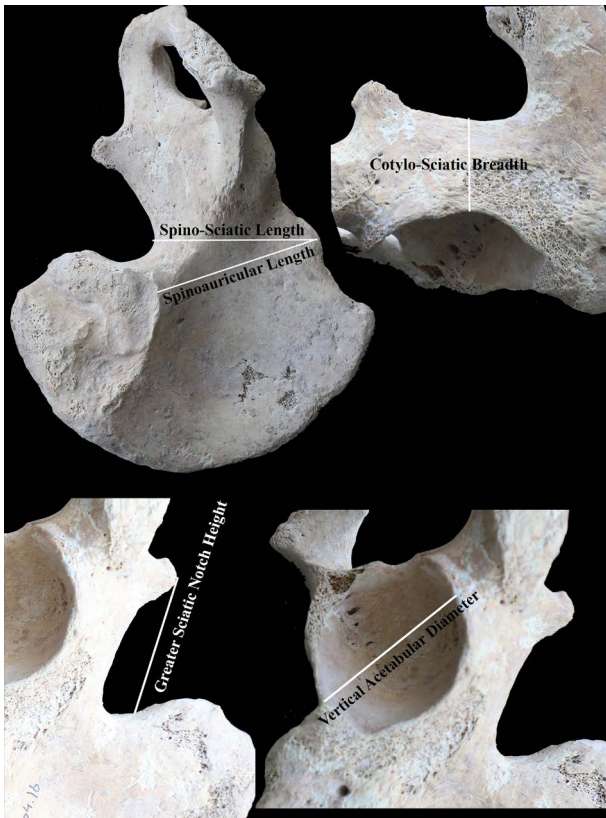


Figure 5: The examination involves measuring key landmarks on the os coxae, including sciatic notch depth/height and vertical acetabular diameter, as illustrated in the figure (Photography and Marking by Author).

1009). Sciatic notch depth/height (Figure.5) results in a t-value of -2.584 and a p-value of .015, with means of 39.9 (male) and 47.2 (female). Spino-sciatic length (Figure.5) has a t-value of 3.412 and a p-value of .001, means of 71.8 (male) and 65.2 (female). Cotylo-sciatic breadth (Figure.5) displays a t-value of 2.398 and a p-value of .021, with means of 35.8 (male) and 33.5 (female).

Four skeletal measurements revealed statistically significant differences between males and females (Table.2). These measurements were as follows. Ischial Length (Figure. 3), measured from the superior margin of the acetabular notch to the most distant point on the ischium, had a t-value = 2.562 and a p-value = .02, with mean scores of 93.6 (males) and 82.9 (females) (Haas *et al.* 1994: 438; Martin 1928: 1009). Sciatic Notch Depth/Height (Figure.5) showed a t-value = -2.584 and a p-value = .015, with means of 39.9 (males) and 47.2 (females) (Schultz, 1930; Tague, 1992). Spino-Sciatic Length (Figure.5) exhibited a t-value = 3.412 and a p-value = .001, with means of 71.8 (males) and 65.2 (females) (Standing 2021: 367). Finally, Cotylo-Sciatic Breadth (Figure.5) reported a t-value = 2.398 and a p-value = .021, with means of 35.8 (males)

and 33.5 (females) (Gray *et al.*, 1995: 1120; Krogman and İşcan, 1986). These results are summarised as significant ('Yes') in Table 2 and Figure.4

The statistical chart (Figure.4) outlines gender differences in this study, enabling comparisons of measurement distributions between sexes. This visualisation highlights significant disparities and focuses on variability in measurements by sex (Chambers 2018). The boxplot examines median values, interquartile ranges, and potential outliers for each measurement, which are crucial for understanding anatomical distinctions. It also helps elucidate mean differences across various metrics between males and females, providing a comprehensive overview of gender-related data insights (Figure.4).

Pelvic Nonmetric Measurement

Nonmetric measurements emphasise qualitative attributes rather than precise numerical values. Relative nonmetric assessments allow for comparisons or rankings without exact values. In pelvic trait studies, variables were ranked from 1 (absolute female) to 5 (absolute male), showing sex transition with intermediate scores.

Sex differences were assessed using ordinal scales for nonmetric traits, such as sciatic notch shape (1=widest U-shape to 5=narrowest V-shape), ventral arc ridge (1=present, 2=unknown, 3=absent), subpubic concavity (1=concave, 2=unknown, 3=straight/convex), and ischiopubic ramus edge (1=sharp, 2=intermediate, 3=blunt) (Table. 3).

Description for Table 3. 1: Variable lists the anatomical features being analysed; 2: Sex indicates the sex categories, Male (M) and Female (F), for which data is presented; 3: N (%) shows the sample size in number and as a percentage; 4: Crosstabs (N/%) presents the counts and percentages for different categories or observations within each anatomical feature, broken down by sex (e.g., 1-5 for Sciatic Notch, 1-3 for Ventral Arc Ridge etc.); 5: Sig represents the significance obtained from the statistical test; 6: Yes/No likely indicates whether the difference between sexes for that variable is statistically significant (Yes) or not (No) based on the p-value.

Sciatic Notch: The greater sciatic notch, located beneath the posterior inferior iliac spine, allows the passage of the piriformis muscle and pelvic nerve to the lower limb (Figure.6). It features the thickest cortical bone in the os coxae (Standing 2021: 377; White *et al.* 2011: 417). For the sciatic notch variable, there were 28 males (50.9%) and 27 females (49.1%). Crosstabulation shows the distribution of counts across 5 categories (1-5) for the sciatic notch

by sex. Notably, 0% of males fell into category 1, while 37.0% of females did. The P-value is .000, which is highly statistically significant. This indicates a significant difference in the distribution of sciatic notch characteristics between males and females, marked as “Yes” for significance (Table. 3) (Figure.7).

Ventral Arc Ridge: It is a significant anatomical feature found on the pelvis, specifically on the ventral (anterior) surface of the pubic bone (os pubis). It’s a bony ridge on the pubis. Dissections have shown that it serves as an attachment site for various muscles, including the gracilis and adductor brevis, and the ventral pubic ligament. This feature gained

Table. 3:Qualitative dependent variables and their level of significance concerning predefined sexes. ** P<0.05

Variable ¹	Sex ²	N (%) ³	Crosstabs (N/%) ⁴				Sig. (p) ⁵	Yes/No
Sciatic Notch	M	28 (50.9)	Count = 1-5 Crosstabulation				.000**	Yes
	F	27 (49.1)	0 (0.0%)	4 (14.3%)	6 (21.4%)	12(42.9%)		
Ventral Arc Ridge	M	20 (66.7)	Count = 1-3 Crosstabulation				.070	No
	F	10 (33.3)	1 (5.0%)	5 (25.0%)	14 (70.0%)	3 (30.0%)		
Subpubic Concavity Edge	M	20 (66.7%)	0 (0.0%)	9 (45.0%)	11 (55.0%)	.018	Yes	
	F	10 (33.3%)	3 (30.0%)	5 (50.0%)	2 (20.0%)			
Ischiopubic Ramus Edge	M	19 (67.9%)	2 (10.5%)	7 (36.8%)	10 (52.6%)	.130	No	
	F	9 (32.1%)	4 (44.4%)	2 (22.2%)	3 (33.3%)			

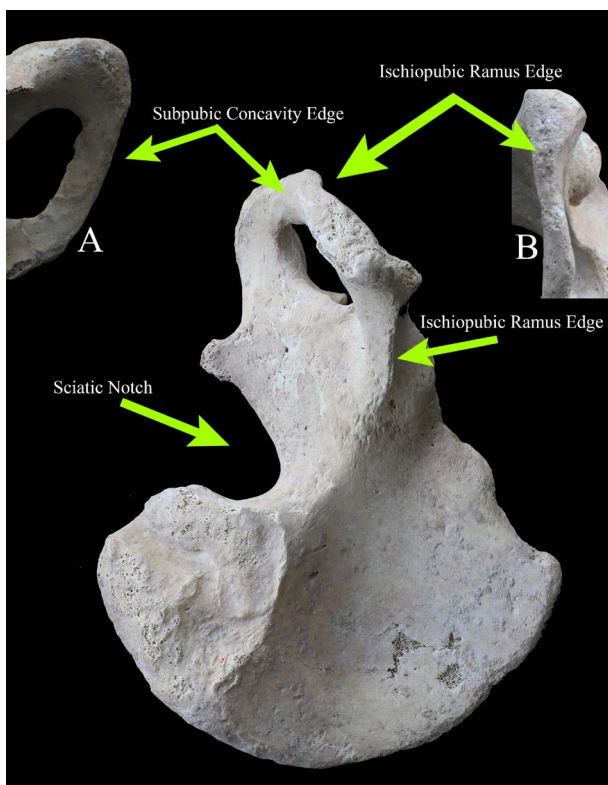


Figure. 6: Qualitative landmarks measured in this study. The yellow arrows indicate the locations where the scores are ordinarily assessed. A: A close-up view of the Subpubic Concavity Edge; B: A detailed examination of the Ischiopubic Ramus Edge (Photography and Marking: by Author).

prominence with the Phenice method (Phenice, 1969), a widely used technique for visually determining sex from the pelvis.

For the ventral arc ridge, there were 20 males (66.7%) and 10 females (33.3%). Crosstabulation presents counts for 3 categories (1-3). The significance value is .070, which is greater than the common threshold of 0.05, suggesting no statistically significant difference in the ventral arc ridge characteristics between males and females, marked as “No” for significance (Table. 3) (Figure.7).

Subpubic Concavity Edge: Females generally display a subpubic concavity (Figure.6: A) with a smoother, rounded edge along the inferior pubic ramus, while males tend to have straighter or minimally concave edges that appear sharper. These distinctions align with pelvic structural adaptations for function and biomechanics (Bass 2005: 122; Haas et al. 1994: 19-21; White et al. 2011: 419). For this variable, the analysis revealed 66.7% males and 33.3% females. Counts are shown for 3 categories. The p-value is .018. This p-value is less than 0.05, indicating a statistically significant difference in the pubic concavity edge characteristics between males and females, marked as “Yes” for significance (Table. 3) (Figure.7).

Ischiopubic Ramus Edge: The ischiopubic ramus, which combines the ischium and pubis bones, shows sexual dimorphism: males have thicker rami for muscle attachment, while females have thinner rami that help childbirth (Phenice 1969). The variable included 19 males and 9 females, with counts displayed across three categories labelled 1 through 3. The p-value is .130, which exceeds 0.05, suggesting no statistically significant difference in the ischiopubic ramus edge characteristics between males and females, denoted as No for significance (Table. 3) (Figure.7).

The analysed data (Figure.7) compares anatomical variables of male and female specimens using bar plots, showcasing sex-based differences. It identifies statistically significant variations and highlights differences in trait frequency, offering qualitative evidence of sexual dimorphism in pelvic structure.

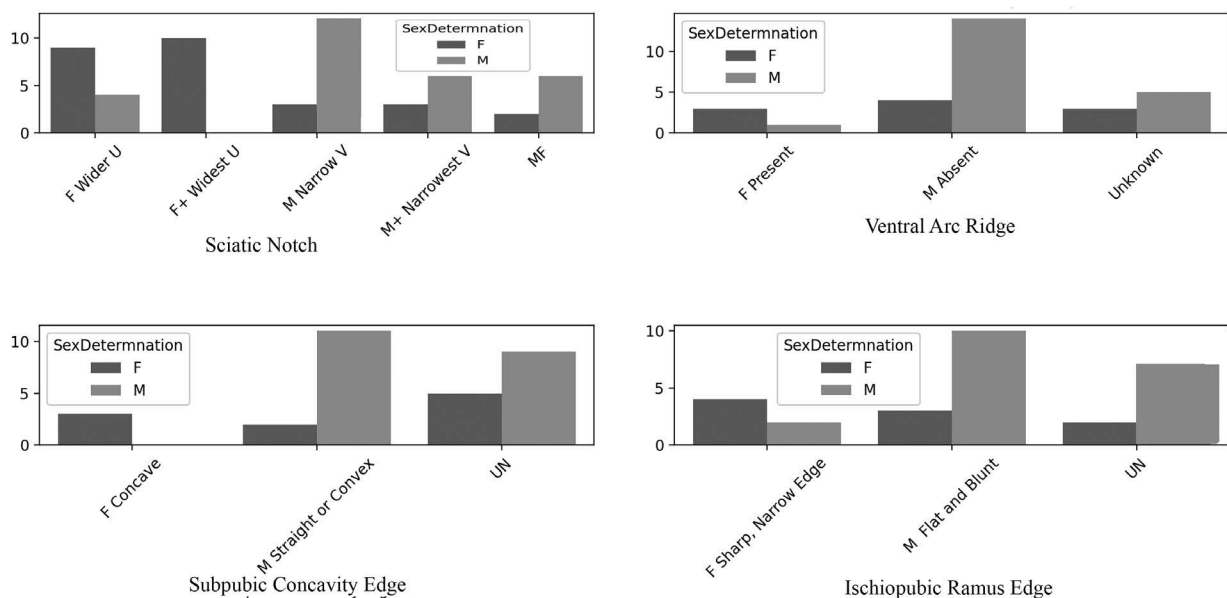


Figure. 7: The chart compares four different skeletal measurements between males and females.

Conclusion

The primary objective of this research is to address whether the standard methodologies of sex determination in osteology can be universally applied, both metrically and non-metrically, across different populations and local communities. Answering this question involves statistical analysis to reveal key relationships between sexual characteristics, despite the limitations posed by population diversity and the influence of natural selection. Key findings

indicate a strong association of sexual dimorphism with metric variables, such as sacral middle breadth, sacral transverse diameter, ischial length, sciatic notch depth, spino-sciatic length, and cotylo-sciatic breadth, and non-metric variables, such as the sciatic notch, ventral arc ridge, and subpubic concavity edge. However, some variables showed limited consistency, likely due to sample size constraints and demographic diversity. An increase in sample size or changes in the sample population could potentially alter these findings.

The pelvis, which exhibits notable sexual dimorphism, plays a crucial role in sex determination. Combining visual methods, such as the Phenice technique, with metric analyses enhances the accuracy of this process. This study highlights the importance of developing population-specific standards and underscores the need for further research involving larger and more diverse samples to improve tech-

niques in forensic anthropology and bioarchaeology. Among the factors analysed, visual traits, qualitative variables, and distinctive markers were found to be more reliable, whereas quantitative variables were relatively less effective for universal sex determination. Furthermore, evidently, visual and metric methods can yield differing outcomes, influenced by variations in sample size and population composition.

Given that increasing the sample size could potentially lead to different results, this study recommends conducting more varied statistical tests with larger sample groups. These samples should include single-sex communities, such as women from various regions, or more diverse sexual population pools (men and women) to achieve more reliable outcomes. The current findings are constrained by the limited sample size and cannot be fully generalised to other populations in Guilan and Iran. Another recommendation for future projects in this field is to ensure an equal number of male and female samples within a community. This approach would lead to more accurate statistical results and enhance the generalisability of the findings.

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