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Research Paper: Comparing the Accuracy of Morphometric and Morphological Criteria of Hip Bone in Gender Determination

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ABSTRACT

Background: A primary aim of forensic medicine is gender determination. Although hip is the optimal bone for this purpose, different determining criteria of this bone do not have the same accuracy. This is important in conditions that only parts of hip remain to determine gender. This study aimed to evaluate the accuracy of different hip criteria in gender determination.

Methods: This cross-sectional study evaluated a total of 160 paired hips (80 males and 80 females) removed from the bodies for bone transplantation. Morphometric criteria were vertical and horizontal acetabular diameters and superior and inferior pubic ramus widths. Morphological criteria were a greater sciatic notch, obturator foramen, pubic body, preauricular sulcus, acetabular fossa position, and ischial tuberosity. The obtained data were analyzed using Cross Tab, t-test, and logistic regression analysis by SPSS. The significance level was set at $P<0.05$.

Results: There was no significant difference in morphometric and morphological criteria between the studied left and right hip bones ($P>0.05$). In gender determination, acetabular diameter and greater sciatic notch had the highest accuracy (85%), and obturator foramen (67.5%) and superior and inferior pubic ramus widths (65%) had the lowest accuracy.

Conclusion: Hip bone is not always completely available and preserved to determine gender. Moreover, sometimes not all anthropometric criteria of the bone are in favor of one gender. Therefore, investigating the accuracy of different criteria can be very important in interpreting the results. Thus, it has always been emphasized on the use of all available information in gender determination.

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1. Introduction

One of the most well-known problems in forensic medicine is body identification and gender determination using skeletal remains, especially in conditions such as trauma, natural disasters, and criminal cases [1, 2]. Bones are influenced by various factors, including age, race, genetics, and environmental conditions, and remain for a long time. Thus, gender determination is a primary step in forensic identification [2, 3]. The hip bone is the most important bone with highest accuracy levels in gender determination; different characteristics of this bone has been previously studied [4-7].

Different hip bone criteria do not have the same value and accuracy in gender determination [2, 8]. In this regard, Phenice et al. reported a 95% accuracy for the pubic bone [9]. Takahashi et al. recognized greater sciatic notch as the best discriminating variable, with an accuracy of 91% in Japanese adults [10]. Nagesh et al. reported 83% and 81% accuracy levels of the acetabulum–pubis index for male and female Indians, respectively [7].

A problem with relying on the hip to determine gender is that hip bone is not always completely available and preserved because pubis is fragile and susceptible to damage [3, 11]. Moreover, not all anthropometric criteria of this bone are necessarily in favor of male or female gender [11]. Therefore, it is important to evaluate the accuracy of each morphometric or morphological criteria for gender determination.

Skeletal characteristics vary among populations. Thus, each population should have specific morphometric and morphological standards to optimize the accuracy of forensic identification [7, 12]. There is limited access to recent bone samples. Studies on the accuracy of different hip criteria in various races are scarce. Therefore, this study evaluated the hip bones removed for bone transplantation. The present study aimed to compare the accuracy of morphometric and morphological criteria of the hip bone in sexing among an Iranian population.

2. Materials and Methods

This cross-sectional study was conducted on a total of 160 paired hips (80 males and 80 females) in Tehran University of Medical Sciences in 2017 and 2018.

This study was performed on the cadavers, referred to the Legal Medicine Organization, for autopsy and cause of death determination. The hip bones were removed from bodies for bone transplantation and sent to the Tissue Bank and Research Center of Tehran University of Medical Sciences. Informed consent for the research was obtained from the first degree relatives of the cadavers. This study was approved in the Ethics Committee of Tehran University of Medical Sciences (code: 93-04-30-27204).

The bone samples of Iranian subjects older than 18 years were included in the study and those with a history of trauma or skeletal malformation were excluded. First, the bone was cleansed by a scalpel to remove any soft tissue. Considering the importance of sterility of the samples for transplantation, the examinations were conducted under sterile conditions. An experienced specialist blinded to bone genders performed the criteria examinations.

Morphometric criteria were the vertical acetabular diameter (the maximum diameter of the acetabulum measured in a superior-inferior direction) [13], horizontal acetabular diameter (the maximum diameter of the acetabulum measured in a horizontal direction) [13], superior ramus width (the minimum width of superior pubic ramus) [13], and inferior ramus width (the minimum width of inferior pubic ramus) [13]. These criteria were measured by a caliper (in cm). Morphological criteria included the greater sciatic notch, obturator foramen, pubic body, preauricular sulcus, acetabular fossa position, and ischial tuberosity. The obtained data were analyzed by Cross Tab, t-test, and regression in SPSS. The significance level was set at $P<0.05$.

3. Results

This study was conducted on 320 hips (80 males and 80 females). The samples Mean±SD age was 39.58±12.56; 36.65±14.28 for the males and 42.50±10.09 for females. There was no significant difference between genders regarding age ($P>0.05$) (Table 1). There was no significant difference between the left and right hip bones, in terms of morphometric criteria ($P>0.05$). The vertical and horizontal acetabular diameters and superior and inferior ramus widths were significantly higher in males, compared to females ($P<0.05$) (Table 2).

According to the significant differences observed between the genders, ROC curves were drawn to assess the precision of morphometric criteria in gender determination. The Area Under the Curve (AUC) for ROC curves are presented in Table 3. Regarding morphometric criteria, the vertical and horizontal acetabular diameters had the highest accuracy (85%), and the inferior pubic ramus

Table 1. The age details of studied males and females (year)

Gender	Mean±SD	Minimum	Maximum	No.
Male	36.65±14.28	18	58	80
Female	42.50±10.09	24	63	80
Total	39.58±12.56	18	63	160

Table 2. The Mean±SD and minimum and maximum of morphometric criteria in studied male and females

Parameter (cm)	Male				Female			P*
	Side	Mean±SD	Min.	Max.	Mean±SD	Min.	Max.	
Vertical acetabular diameter	Right	4.70±0.40	3.9	5.2	3.84±0.86	3.0	4.4	<0.0001
	Left	4.68±0.42	3.9	5.4	4.06±0.25	3.6	4.6	<0.0001
Horizontal acetabular diameter	Right	4.92±0.39	4.2	5.5	4.24±0.21	3.8	4.6	<0.0001
	Left	4.88±0.43	4.2	5.6	4.24±0.21	3.9	4.7	<0.000
Superior pubic width	Right	1.72±0.34	1.2	2.5	1.56±0.25	1.0	2.1	0.04
	Left	1.78±0.33	1.3	2.4	1.55±0.21	1.1	1.8	0.012
Inferior pubic ramus width	Right	1.44±0.27	1.1	2.1	1.21±0.18	0.9	1.5	0.003
	Left	1.52±0.32	1.0	2.2	1.26±0.25	0.8	1.9	0.007

* P<0.05 is considered as statistically significant.

width had the lowest accuracy (65%). The obtained results of the morphological criteria for males and females are listed in Table 4. The frequency of greater sciatic notch shape significantly differed in males and females (P<0.05).

In males, 90% of the right and 80% of the left hip bones were J-like and J-shaped, respectively; in females, 75% of the right and 80% of the left hips were L-like and L-shaped, respectively. In addition, the greater sciatic notch was not judicious in 5% of the right and 10% of the left hip bones in males, and 10% of the right and 5% of the left hip bones in females. Obturator foramen shape was significantly different between the two genders (P<0.05). A total of 70% were oval-shaped in males and 70% were triangle-shaped in the females.

Regarding the shape of the pubic body, a significant difference was observed in males and females (P<0.05). It was triangle-shaped in 70% of the males and rectangle-shaped in 70% of the female samples. Based on Table 4, the preauricular sulcus was present in 50% and 10%

Table 3. The sensitivity, specificity, positive and negative predictive values and precision of morphometric criteria

Parameter	Demarking point*	Sensitivity	Specificity	Predictive Value		Accuracy (%)
				Positive	Negative	
Vertical acetabular diameter	4.25	87.5	82.5	84	86.5	85
Horizontal acetabular diameter	4.45	87.5	83	82.5	86.5	85
Superior pubic ramus width	1.65	60	65	63.2	61.9	65
Inferior pubic ramus width	1.25	80	50	61.5	71.4	65

* Centimeter.

Table 4. Morphological criteria of the hip bone in males and females

Parameter		Right				Left			
		Male		Female		Male		Female	
		No.	%	No.	%	No.	%	No.	%
Greater sciatic notch	J-Like	20	25	8	10	12	15	4	5
	J-Shape	52	65	4	5	52	65	8	10
	L-Like	0	0	20	25	4	5	24	30
	L-Shape	4	5	40	50	4	5	40	50
	Undetermined	4	5	8	10	8	10	4	5
Obturator foramen	Oval	56	70	24	30	56	70	24	30
	Triangle	24	30	56	70	24	30	56	70
Pubic body	Triangle	56	70	24	30	56	70	24	30
	Rectangle	24	30	56	70	24	30	56	70
Preauricular Sulcus	Present	8	10	40	50	4	5	40	50
	Absent	72	90	40	50	76	95	40	50
Acetabular fossa position	Anterior	12	15	52	65	12	15	44	55
	Lateral	36	45	4	5	44	55	4	5
	Anterolateral	32	40	24	30	24	30	32	40
Ischial tuberosity	Eversion	32	54	48	67	32	42	44	65
	Inversion	8	13	0	0	8	11	0	0
	Undetermined	20	33	24	33	36	47	24	35

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of the right side samples of females and males, as well as 50% and 5% of the left side samples of females and males, respectively; these differences were statistically significant (P<0.05).

Regarding acetabular fossa position, 85% were lateral and anterolateral in both right and left side samples of males; moreover, 65% of right and 55% of left side samples were anterior in females; these differences were statistically significant between genders (P<0.05). Due to trauma, we excluded investigating ischial tuberosity position in 28 right hips (20 males and 8 females) and 16 left hips (4 males and 12 females) after removal from the body. In the males, 54% of the right and 42% of the left hip bone samples had eversion and in the females, 67% of the right and 65% of the left bone samples had eversion; the difference was not statistically significant between genders (P>0.05).

Logistic regression analysis was applied to measure the accuracy of morphological criteria. The accuracy of these criteria were 85% for the greater sciatic notch, 75% for acetabular fossa position, 72.5% for pubic body, 71% for the presence of preauricular sulcus, and 67.5% for obturator foramen. There was no statistically significant difference between the left and right side samples regarding these criteria (P>0.05).

The accuracy of criteria in gender determination was 85% for the acetabular diameter and greater sciatic notch; the same for the acetabular fossa position, pubic body, preauricular sulcus, obturator foramen, and pubic ramus width were 75%, 72.5%, 70%, 67.5%, and 65%, respectively.

The logistic regression formula to estimate gender was obtained as follows: The final model to estimate gender

based on the greater sciatic notch, acetabular diameter and inferior pubic ramus width (Formula A):

A=(43.145×L-Shape)+(525.698×L-Like)-(79.198×J-Shape)+(5.257×J-Like)+(115.871×Horizontal Acetabulum Diameter)-(278.301×Vertical Acetabulum Diameter)-(103.779×Inferior Pubic Ramus)+883.108

In this formula, based on the shape of the greater sciatic notch, "1" in related parts, and in other parts, "0" (zero) are placed. The final model to estimate gender based on the vertical acetabulum diameter and preauricular sulcus (Formula B):

B=(-7.292×Vertical Acetabulum Diameter)+(3.682×Pre-Auricular sulcus)+31.869

In this formula, if the sulcus is present, "1" and if the sulcus is absent, "0" are placed. In both formulas (A or B), values >0 indicated female gender and values <0 were considered as male.

4. Discussion

We compared the accuracy of morphometric and morphological criteria of the hip bone to determine gender in an Iranian population. The hip bone is the most important bone in gender determination [13-16]. Many bones demonstrate gender differences, depending on the size; however, hip presents no size-related gender differences which makes it reliable criteria for gender determination of remaining skeleton [12].

Different morphometric and morphological criteria of this bone have been previously studied. Singh et al. reported that the accuracy of the greater sciatic notch to determine gender in adult Indian population was 100% [13]. Moreover, the accuracy of hip regarding morphological and morphometric criteria is 95% in gender determination [7, 17].

In bone studies, it is emphasized to determine gender by different bones and the most possible varied criteria [2]. Thus, we used both morphometric and morphological criteria in this study. The difference between the two sides of the skeleton is not significant to constitute a source of error in the determination of skeletal status [18, 19]. In our study, there was no significant difference in morphometric and morphological criteria between the right and left hip bones (P>0.05).

The obtained mean scores of vertical acetabular diameters in males and females were lower than those of Patriquin et al. on white and black South African population, Gonzalez et al. on Portuguese population, Steyn et al. on Modern Greek people, Nagesh et al. and Mukhopadhyay et al. on adult Indian population, and Takashi et al. on Japanese population [7, 10, 14, 16, 15, 20]. This difference can be related to differences in race, nutrition, environmental factors or evaluating this prominence in respect of morphometric criteria [21].

Consistent with the findings of Patriquin et al. Takahashi et al. Naghash et al. Steyn et al. Gonzalez et al.Mukhopadhyoy et al. and El-najjar et al. the mean scores of vertical and horizontal acetabular diameters were higher in males, than females [7, 10, 14, 15, 20, 22, 23]. The accuracy of acetabular diameter in this study was 85% which was similar to the results of Takashi et al. (85%) and Patriquin et al. (84%) [10, 15]. Furthermore, Dixit et al. reported that vertical acetabular diameter is the most optimal criterion for gender determination [12].

In this article, the superior and inferior pubic ramus widths in males were significantly higher than females (P<0.05). No study was found on the pubic ramus width. Only Dolinak et al. stated that the superior pubic ramus is wider than the inferior one in females; where the ratio of upper to the lower horn is 1:1 in males and 2:1 in females [24]. There was no study on its accuracy in gender determination. Moreover, our study failed to suggest it as a highly accurate criterion.

The obtained data revealed the best morphometric criterion to determine gender was the acetabular width (accuracy: 85%) and the least accurate criterion was the upper pubic ramus width (accuracy: 65%). There was a statistically significant difference between these morphometric criteria. The achieved results suggested a significant difference between male and female gender in terms of the greater sciatic notch, obturator foramen, pubic body, acetabular fossa position and preauricular sulcus (P<0.05). Our obtained results were in line with those of Walker et al. on the hip bone remains of English, European and African Americans, as well as Bruzek et al. on the hip bone of French and Portuguese populations, and Bardale et al. Saukko et al. Phenice et al,. and El-Najjar and colleagues [2, 3, 5, 8, 9, 22].

There was no significant difference in ischial tuberosity between genders (P>0.05) which was in contrast with the results of Bradele et al. and El-Najjar and associates [8, 22]. The aforementioned studies disregarded the accuracy and value of this criterion. However, perhaps this difference is related to factors such as race, genetics, en-

Table 5. Comparison between studies on hip anthropologic criteria

Study	Methods	Population	Criteria	Result												
Patriquin et al. [15]	Direct	Black and White African and European	Vertical acetabulum diameter (mm)	Race	Male					Female					P *	Accuracy (%)
				White	56					51					<0.05	81.5
				Black	55					49					<0.05	83.5
Steyn et al. [16]	Direct	Greek	Vertical acetabulum diameter (mm)	Modern Greek	55					49					<0.05	83.9
Mukhopadhyay et al.[21]	Direct	Indian	Vertical acetabulum diameter (mm)	Indian	53					48					<0.05	
Phillip L. Walker [3]	Direct	Black and White European and African Americans	Greater sciatic notch		J-Liked	J-Shaped	L-Liked	L-Shaped	Undetermined	J-Liked	J-Shaped	L-Liked	L-Shaped	Undetermined		
				European American	22	9	34	5	29	0	2	32	56	10	<0.05	
				African American	18	7	45	5	25	4	0	36	56	0	<0.05	
				English	8	0	51	12	29	0	0	12	85	3	<0.05	
The present Study	Direct	Iranian	Vertical acetabulum diameter (mm)	white	47					38					<0.05	85
			Greater sciatic notch	white	J-Liked	J-Shaped	L-Liked	L-Shaped	Undetermined	J-Liked	J-Shaped	L-Liked	L-Shaped	Undetermined	<0.05	85
					20	65	2.5	5	7.5	7.5	7.5	27.5	50	7.5		

* P<0.05 is considered as statistically significant.

vironmental conditions, research methodology, and criterion evaluation (i.e. morphological criterion) [3, 21].

Based on our study, the accuracy of greater sciatic notch in sexing was 85% which was similar to the measured accuracy of studies by Gonzalez et al. on Portuguese population and Takahashi and associates [10, 14]. Singh et al. reported a 100% accuracy of this criterion for adult Indian hip bones; however, Saukko et al. reported this accuracy equal to 75% [2, 13]. This difference can be related to differences in race, research methodology, or evaluation method [3, 21]. Studies overlooked the accuracy of other morphologic criteria in gender determination. The obtained results of comparing the previous research on the accuracy of hip anthropometric criteria with our study are presented in Table 5.

According to the obtained results, the most optimal hip bone criteria in gender determination were acetabular diameter and greater sciatic notch (accuracy: 85%), and the least accurate criteria were obturator foramen shape (accuracy: 67.5%) and the superior and inferior pubic ramus width (accuracy: 65%). It was impossible to examine all anthropologic criteria of the hip, due to the impossibility of completely removing the bone, injury to the hip during removal from the body or the removal of its soft tissue; however, this study was valuable considering that it was conducted on a large and significant number of fresh bones of one race.

5. Conclusion

A problem with relying on using hip bone to determine gender is that hip bone is not always completely available and preserved; because pubis is susceptible to damage and fragile. Moreover, not all anthropometric criteria are in favor of a single gender. Therefore, we aimed to compare the accuracy of morphometric and morphological criteria of the hip bone in sexing among an Iranian population. According to the obtained results, the most optimal hip bone criteria in gender determination were acetabular diameter and greater sciatic notch; the least accurate criteria were the superior and inferior pubic ramus widths and obturator foramen shape. Acetabular foramen position, pubic body shape, and preauricular sulcus had the same accuracy levels.

It has always been emphasized on the use of all available information and samples in gender determination. Although racial differences can affect the accuracy of these criteria, it is essential to determine them in gender identification. This is because sometimes disasters and accidents occur in areas where diverse races live together.

Ethical Considerations

Compliance with ethical guidelines

Informed consent for the research was obtained from the first degree relatives of the cadavers. This study was approved in the Ethics Committee of Tehran University of Medical Sciences (code: 93.04.30.27204).

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Authors' contributions

All authors contributed in designing, running, and writing all parts of the research.

Conflict of interest

The authors declared no conflict of interest.

References

[1] Sinha AP, Kumari A, Ali S, Jethani S. Morphometric study of distance between posterior inferior iliac spine and ischial spine of the human hip bone for sex determination. International Journal of Research in Medical Sciences. 2017; 2(2):718-20. [DOI:10.5455/2320-6012.ijrms20140565]

[2] Saukko P, Knight B. Knight's forensic pathology. 4th edition. Boca Raton: CRC Press; 2004.

[3] Walker PL. Greater sciatic notch morphology: sex, age, and population differences. American Journal of Physical Anthropology. 2005; 127(4):385-91. [DOI:10.1002/ajpa.10422] [PMID]

[4] Siddapur KR, Siddapur GK. Pelvic bone indices as effective parameters of sex determination in skeletal remains: a cross-sectional study. International Journal of Research in Medical Sciences. 2017; 2(4):1526-9. [DOI:10.5455/2320-6012.ijrms20141153]

[5] Bruzek J. A method for visual determination of sex, using the human hip bone. American Journal of Physical Anthropology. 2002; 117(2):157-68. [DOI:10.1002/ajpa.10012] [PMID]

[6] Kim DH, Lee SS, Han SH, Lee UY. A new landmark for measuring the ischium-pubis index for sex determination by using three-dimensional models of South Korean population. Australian Journal of Forensic Sciences. 2018; 50(5):472-81. [DOI:10.1080/00450618.2016.1267796]

[7] Nagesh K, Kanchan T, Bastia BK. Sexual dimorphism of acetabulum-pubis index in South-Indian population. Legal Medicine. 2007; 9(6):305-8. [DOI:10.1016/j.legalmed.2007.05.003] [PMID]

[8] Bardale R. Principles of forensic medicine & toxicology. New Delhi: Jaypee Brothers; 2011. [DOI:10.5005/jp/books/11334]

[9] Phenice TW. A newly developed visual method of sexing the os pubis. American Journal of Physical Anthropology. 1969; 30(2):297-301. [DOI:10.1002/ajpa.1330300214] [PMID]

[10] Takahashi H. Curvature of the greater sciatic notch in sexing the human pelvis. Anthropological Science. 2006; 114(3):187-91. [DOI:10.1537/ase.051111]

[11] Iscan MY, Steyn M. The human skeleton in forensic medicine. Illinois: Charles C Thomas Publisher; 2013.

[12] Dixit S, Kakar S, Agarwal S, Choudhry R. Sexing of human hip bones of Indian origin by discriminant function analysis. Journal of Forensic and Legal Medicine. 2007; 14(7):429-35. [DOI:10.1016/j.jflm.2007.03.009] [PMID]

[13] Singh S, Potturi BR. Greater sciatic notch in sex determination. Journal of Anatomy. 1978; 125(Pt3):619-24. [PMID] [PMCID]

[14] Gonzalez PN, Bernal V, Perez SI. Geometric morphometric approach to sex estimation of human pelvis. Amsterdam: Elsevier; 2009. [DOI:10.1016/j.forsciint.2009.04.012]

[15] Patriquin M, Steyn M, Loth S. Metric analysis of sex differences in South African black and white pelves. Forensic Science International. 2005; 147(2-3):119-27. [DOI:10.1016/j.forsciint.2004.09.074]

[16] Steyn M, İşcan M. Metric sex determination from the pelvis in modern Greeks. Forensic Science International. 2008; 179(1): 86.e1-86.e6. [DOI:10.1016/j.forsciint.2008.04.022]

[17] Krogman WM. Determination of sex and parturition. In: Krogman WM, İşcan MY, editors. The Human Skeleton in Forensic Medicine. Illinois: Charles C Thomas Publisher; 1986.

[18] Dreizen S, Snodgrasse RM, Webb-peploe H, Parker GS, Spies TD. Bilateral symmetry of skeletal maturation in the human hand and wrist. AMA Journal of Diseases of Children. 1957; 93(2):122-7. [DOI:10.1001/archpedi.1957.02060040124004]

[19] Torgersen J. Asymmetry and skeletal maturation. Acta radiologica. 1951; 36(6):521-3. [DOI:10.3109/00016925109177005]

[20] Mukhopadhyay PP. Determination of Sex by Sciatic Notch/Acetabular Ratio (Kelley's Index) in Indian Bengali Skeletal Remains. Journal of Indian Academy of Forensic Medicine. 2012; 34(1):27-30.

[21] Montagu M, Brožek JC. A handbook of anthropometry. Whitefish: Literary Licensing; 1960. [DOI:10.1037/12018-000]

[22] El-Najjar MY, McWilliams KR. Forensic anthropology: the structure, morphology, and variation of human bone and dentition. Illinois: Charles C Thomas Publisher; 1978.

[23] Steyn M, Patriquin ML. Osteometric sex determination from the pelvisâ€"Does population specificity matter? Forensic Science International. 2009; 191(1-3):113.e1-5. [DOI:10.1016/j.forsciint.2009.07.009]

[24] Dolinak D, Matshes E, Lew EO. Forensic pathology: Principles and practice. Amsterdam: Elsevier; 2005.