DOI: 10.21088/ija.2320.0022.14325.3

Indian Journal of Anatomy
Volume 14 Number 3 September - December 2025

ORIGINAL ARTICLE

Morphometric Study of Anterior Border of Human Hip Bone in the Maharashtra Region

Vivek Kishanrao Nirmale[1], Shashank Bhaskarrao Vedpathak[2], Ashwini Vijay Bhele[3]

HOW TO CITE THIS ARTICLE:

Vivek Kishanrao Nirmale, Shashank Bhaskarrao Vedpathak, Ashwini Vijay Bhele. Morphometric Study of Anterior Border of Human Hip Bone in the Maharashtra Region. Ind Jr Anat. 2025; 14(3): 95-99.

ABSTRACT

Introduction: Identification of sex from skeleton remains is of great medicolegal, anthropological and archaeological importance. It is acknowledging that the hip bone is by far the best non-population specific indicator for reliable sex determination.

Material and Methods: 178 Adult hip bones (54 females and 124 males) of known sex were used for the present study. We calculated Index of widening of anterior border (INDEX I), Index of widening of ant. Interspinous notch (INDEX II) and Index of widening of notch between anterior inferior iliac spine and the iliopubic eminence (INDEX III). For all these indices, we measured range, mean, standard deviation, P value and demarcating points. All the observations were tabulated, analyzed statistically and compared with the previous studies. We applied "Multivariate Linear discriminant function" as proposed by Armitage.

Observations and Results: We found that if these three indices used in combination can achieve the accuracy rate of 62.10% in males and 61.80% in females with overall accuracy of 61.80%.

Conclusion: All the three indices in our present study are statistically significant and can be used effectively for sex determination.

KEYWORDS

• Hip bone • Medicolegal • Anthropological and Sex determination

AUTHOR'S AFFILIATION:

[1] Professor, Department of Anatomy, M.I.M.E.R. Medical College, Talegaon (D), Pune, Maharashtra, India.

[2] Professor and Head, Department of Anatomy, M.I.M.E.R. Medical College, Talegaon (D), Pune, Maharashtra, India.

[3] Assistant Professor, Department of Anatomy, M.I.M.E.R. Medical College, Talegaon (D), Pune, Maharashtra, India.

CORRESPONDING AUTHOR:

Nirmale Vivek Kishanrao, Professor, Department of Anatomy, M.I.M.E.R. Medical College, Talegaon Dabhade, Pune, Maharashtra, India.

E-mail: vivnir1101@gmail.com

➢ **Received:** 14-08-2025 ➢ **Accepted:** 14-10-2025

INTRODUCTION

Sex determination plays a key role in all osteological studies.[1,2] Hip bone is one of the most reliable bone used for sex determination because it not only reflects modifications due to bipedal locomotion but also special adaptation for childbearing in females.

The hip bone is a large irregular bone which because of its non-resemblance to any common objects is often called the innominate bone. It consists of three parts, the ilium, ischium and pubis, which are distinct from each other in the young subject, but are fused, in the adult; it is constricted in the centre and expanded above and below. It meets its fellow on the opposite side in the middle line in front, and together they form the sides and anterior wall of the pelvic cavity. The union of the three parts takes place in and around a large cup-shaped articular cavity, the acetabulum.[3,4]

According to Krogman and İşcan[2] 95% accuracy can be obtained if the pelvis is complete, although Bruzek found that accuracies ranged from 59% to 96%. However, it has widely been recognized that skeletal characteristics vary among populations and due to this regional variability; each population should have specific standards to optimize the accuracy of identification.

Previous techniques for sex determination proposed were based on the examination of specific parts of the hip bone including the pubic bone (Phenice, 1969),[5] greater sciatic notch (Kelley, 1979;[6] Letterman, 1941;[7] Mac Laughlin and Bruce, 1986b;[8] Milne, 1990;[9] Singh and Potturi, 1978;[10] Taylor and Di Bennardo, 1984),[11] sacro-iliac joint (Iscan and Derrick, 1984),[12] acetabulum (Schulter-Ellis *et al.* 1983),[13]

In the present study we used three indices related to the anterior border of hip bone and we try to find out the reliability of these indices in sex determination.

MATERIALS AND METHODS

One hundred and seventy-eight adult human hip bones were studied, from both genders and unknown ethnicity. Out of 178 hip bones 54 were of females and 124 of males. All the hip bones were dry, free of damage or deformity and were fully ossified. The personal record of all the hip bones for sex and race are all available with the bone bank, department of Anatomy, Government Medical College, and Aurangabad.

The instruments which used are used for the measurements of various parameters of the hip bone are Scale, Divider, Protector, marker pencil and pens.

For each hip bone we measured the following parameters.

1. The maximum width of the anterior border notch: It is the distance from the anterior superior iliac spine to the superior most aspect of public symphysis, is measured in cm. by using scale.
2. The maximum depth of the anterior border: is measured in cm. by using scale and divider.
3. Index of widening of anterior border (INDEX I) i.e. Index of widening of anterior border is obtained by using following formula.

$$\frac{\text{Depth of the notch} \times 100}{\text{Maximum width of notch}}$$

4. The maximum width of the anterior interspinous notch i.e. the distance between anterior superior iliac spine and anterior inferior iliac spine, is measured in cm. by using scale and divider.
5. Depth of the interspinous notch is measured in cm. by using divider.
6. Index of widening of ant. Interspinous notch (Index II) i.e. obtained by following formula.

$$\frac{\text{Depth of the notch} \times 100}{\text{Maximum width of notch}}$$

7. The depth of the notch between anterior inferior iliac spine and the iliopubic eminence: is measured in cm. by using scale.
8. The maximum width of the notch between anterior inferior iliac spine and the iliopubic eminence: is measured in cm. by using scale and divider.
9. Index of widening of notch between anterior inferior iliac spine and the iliopubic eminence is obtained by using following formula.

$$\frac{\text{Depth of the notch} \times 100}{\text{Maximum width of notch}}$$

As the first part of the study all the values were arranged in tabulated form and analyzed statistically. The values of mean, range, and standard deviation and P value were obtained for each of these 6 parameters and three indices. Each variable was measured three times at three different sessions by the same observer and the mean value of the three measurements was calculated for each variable of each bone.

Table 1: Statistical analysis of various indices used in the present study

		Index I	Index II	Index III
Male	Range	13.55-30.55	10-28.23	7.29-16.28
	Mean	21.87	18.9	16.153
	Standard Deviation (S.D.)	3.374	4.04	4.352
	D.P.	<12.44	–	–
	% of bones identified	NIL	–	–
Female	Range	16.66-31.91	8.59-29.5	7.21-29.51
	Mean	23.48	17.19	16.483
	Standard Deviation (S.D.)	3.682	4.239	4.678
	D.P.	>31.99	–	–
	% of bones identified	NIL	–	–
	P Value	P< 0.001	P= 0.04	P>0.05

For the second part of the study a standard computer program, which analyses the values like mean, range, and standard deviation etc. and is prepared according to "Multivariate Linear discriminant function" as proposed by Armitage (1971)[14] was used.

OBSERVATIONS AND RESULTS

All the hip bones were measured for six parameters and three indices and observation were statistically analyzed by using t-test. The values for range, mean, Standard Deviation and demarcating points (D.P.) were tabulated.

From the table 1 it was quite obvious that by using individual indices very few numbers of hip bones can be identified correctly. Only index I is statistically significant (P<0.001), Hence even with the help of demarcating points for specified population the number of hip bone which can be identified correctly are very less in number.

As a second part of study, multivariate linear discriminant functional analysis is applied to a group of variables designated under one group, and the respective differential functional score is calculated as Z. The indices used in the group are,

1. Index of widening of anterior border (Index I)
2. Index of widening of ant. Interspinous notch (Index II)
3. Index of widening of notch between anterior inferior iliac spine and the iliopubic eminence (Index III).

SPSS (sum of products and sum of squares) was used for applying multivariate linear discriminant analysis.

Discriminant functional score is calculated for all the hip bones and each was analyzed. It is observed that 77 out of 124 male hip bones scored on the male side of Z0 and 33 out of 54 hip bones scored on the female side of Zo. Thus 110 of 178 hip bones are sorted accurately.

DISCUSSION

Anatomists and anthropologists have great interest in the nature and degree of sexual differentiation. It is also having a practical importance from obstetric point of view. Buikstra, Ubelaker (1994)[15] stated that "Estimates of sex therefore can be difficult if the observer is not familiar with the overall pattern of variability within the population from which the sample is drawn overall."

Earlier workers used the usual metrical methods confined to calculate the range, mean value of certain parameters of male and female bones and limiting points of these ranges have been taken as identification points. But method of using identification points for determination of sex is not useful for unknown skeleton.

Jit and Singh (1966) [16] invented "Demarking point" (D.P.) based on statistically calculated ranges of various measurable characters of Punjabi clavicles, which identified sex with 100% accuracy. Though the D.P. evolved by Jit and Singh (1966) do not provide a miracle for identification of sex in 100% of cases but do so with accuracy in whatever number is identified. In the present study also, we found that D.P.s calculated are not of much use for identification of sex in unknown skeleton.

Instead of using index alone if we use all indices in combination with the help of Multivariate linear discriminate analysis the results of the study were strikingly increased. We specifically used anterior border of hip bone so that can be applied on hip bone fragments also.

Table 3: Comparative analysis of the present study with the previous studies

S. no.	Name of the Author	Sample		Index I		Index II		Index III	
				Male	Female	Male	Female	Male	Female
1.	**L Gomez Pellico (1992)** [17]	42 (M-27, F-15)	Mean	24.25	26.60	16.18	14.80	20.73	22.48
			S.D.	2.79	4.94	2.9	2.93	5.12	5.08
			P value	0.004		0.899		0.65	
2.	**Mitesh Shah** *et al* **(2013)**[18]	306 (M-202, F-141)	Mean	22.98	23.73	20.67	18.18	24.98	23.13
			S.D.	3.44	3.88	5.1	4.52	5.52	5.75
			P value	0.106		0.003		0.006	
3.	**Leena Raichandani** *et al* **(2015)**[19]	100 (M-64, F-36)	Mean	22.97	23.73	20.67	18.88	–	–
			S.D.	4.06	3.44	5.09	4.52	–	–
			P value	0.04		0.03		–	
4.	**Present study (2019)**	42 (M-27, F-15)	Mean	21.87	23.48	18.9	17.19	16.15	16.48
			S.D.	3.37	3.68	4.04	4.23	4.35	4.67
			P value	0.0001		**0.04**		**0.05**	

From the above table number 3, it becomes obvious that index II and Index III even though were found of statistically insignificant on the basis of P value, if we use them in combination results are excellent.

The probable reasons for differences in the number and inability to determine the sex of hip bone after applying demarking point method can be 1) The other factors such as genetic, nationality, socioeconomic and physical stress should play their role. 2) The racial differences observed may either be due to environmental or hereditary factors or both.[20]

Rissech (2003)[21] working on pubic growth study on sexual and age diagnostic study confirmed that racial hereditary factors act as primary factor within which functional activities operate as secondary factor.

Table 2: Percentage of hip bones accurately sorted by multivariate analysis

Group of Variables	Percentage of hip bones identified correctly		
	Male	Female	Overall
Group I	62.10%	61.10%	61.80%

CONCLUSION

1. Present study highlights the importance of three hip bone indices which were used less frequently.
2. Instead of using parameters and indices alone if we used them in combination, then results are strikingly improved.
3. Application of this numerical data can be used for anthropological, anatomical, and archaeological studies.

4. In the present study we also discussed the role of responsible factors for sexual dimorphism of hip bone.
5. The additional benefit of the study is even if posterior part of hip bone is damaged, we can use the data because it is restricted to its anterior border.

REFERENCES

1. Bass 1987 – W.M. Bass, Human osteology. A laboratory and field manual. Third Edition (Archaeological Society Publication, N°2, Colombia 1987) p. 327.
2. Krogman, Iscan 1986 – W.M. Krogman/M. Y. Iscan, The Human Skeleton in Forensic Medicine (Tho mas Publisher, Springfield 1986), 551.
3. Aiello Leslie, Dean Christopher. An Introduction to Human Evolutionary Anatomy. London; academic press, 1990.
4. Scheuer Louise, Black, Sue. Developmental juvenile osteology, San Diego: Academic Press. 2000.
5. Phenice T.W. A Newly developed visual method of sexing of os pubis. Am. J. of Phys. Anthrop. 1969; 30: 297-302.
6. Kelly. Sex determination with fragmented skeletal remains. J. of Forensic sci. 1979; 24: 154-58.
7. Letterman, G.S. The greater sciatic notch in American Whites and Negros. Am. J. Phys. Anthrop. 1941; 28: 99-116.
8. McLaughlin S.M. & Bruce M.F. The sciatic notch acetabular index as a discriminator of sex in European skeletal remains. J. of Forensic Sci. 1986; 31: 1380-90.
9. Nicholas Milne. Sexing of human hip bones. J. of Anat. 1990; 172: 221-26.
10. Singh S., Potturi B.R. Greater sciatic notch in sex determination. J. Anat. 1978; 125: 619-24.
11. R. DiBennardo. Multiple discriminant functional analysis of sex and race in the post cranial skeleton. Am. J. phys. Anthrop. 1983; 61: 305-14.
12. Iscan M.Y. Determination of sex from the sacroiliac joint: A visual assessment technique. Florida Sci. 1984; 47: 94–98.
13. Schulter Ellis F.P. Determination of sex with a discriminant analysis of new pelvic bone measurement. J. Forensic. Sci. 1983; 28: 169-80.
14. P Armitage. Statistical Methods in Medical Research fourth edition, Blackwell Publishing Company. 1971.
15. Buikstra J.E., Ubelaker D.H. Standards for data collection from human skeletal remains: proceedings of a seminar at the Field Museum of Natural History, organized by Jonathan Haas. Fayetteville: Arkansas Archaeological Survey. 1994.
16. Jit and Singh. Sexing of the adult clavicle, Ind. J. of Med. research. 1966; 54: 551-71.
17. L. Gomez Pellico, J Fernandez Camacho. Biometry of the anterior border of the human hip bone: normal values and their use in sex determination. J Anat. 1992; 181: 417-22.
18. Mitesh Shah *et al.* Determination of sex from the anterior border of the human hip bone. International journal of medical science and public health 2013; 2(2): 313-16.
19. Leena Raichandani *et al.* Sexual dimorphism Observed in anterior border of human hip bone. International journal of biomedical research. 2015; 6 (01): 22-24.
20. Krishnan K. Anthropology in Forensic Medicine and Forensic Science-Forensic Anthropology' the Internet Journal of Forensic Science. 2007; 2(1).
21. Rissech C. Pubis growth study: Applicability in sexual and age diagnostic. Forensic Sci. Int. 2007; 173 (2-3): 137-45.