

# Morphometrical Analysis of Dry Adult Human Hip Bones by Coxal Index

Meril Ann Soman<sup>1</sup>, Rani Nallathamby<sup>2</sup>

<sup>1</sup>Assistant Professor, <sup>2</sup>Associate Professor,  
Department of Anatomy, Believers Church Medical College & Hospital, Kuttapuzha, Thiruvalla

Corresponding Author: Meril Ann Soman

## ABSTRACT

**Background:** The hip bone is one of the most useful skeletal elements in adult skeleton for sex determination. Hip bone may be used even when fragmentary for both medico legal and archaeological purposes. The aim of the present study is to measure few morphometric parameters of various hip bones and to assess these values both side wise and gender wise.

**Method:** The present study was conducted in department of Anatomy, Yenepoya Medical College, Mangalore. 100 adult dry human hip bones were included in the study, of which 50 were male and 50 were female hip bones. 50 bones belonged to right side and 50 to left side. The morphometrical parameters measured were length, width and weight of the hip bones. Coxal index was also calculated.

**Result:** Range, mean, median, standard deviation and standard error of mean were determined for each parameter. Conclusions were drawn after comparing the values with series of other workers.

**Conclusion:** The values were slightly higher on the left side compared to the bones of the right side and also the values were more in male bones compared to female bones. The study would help the forensic experts and the anthropologists in specimen identification and sex determination from skeletal remains. It would also be valuable for the anatomists and the orthopedicians in their respective fields.

**Key Words:** Hip bone, morphometry, coxal index, sexual dimorphism, hip bone weight

## INTRODUCTION

The important features in establishing the identity of an individual are

sex, age, ethnic background and stature. The features of human skeletal remains can be observed and measured even long after the death of the individual as they are very resistant to time. Therefore the study of sexual dimorphism of human bones is of great interest not only for Anatomists, but also for forensic experts, anthropologists and even archaeologists. Knowledge regarding the average dimensions of the parts of hip bone in both sexes will also help in early detection of disputed sex by Forensic experts. <sup>(1)</sup>

Hip bone is considered as the most reliable bone for sex determination. The sexual dimorphism of hip bone is a special adaption seen in females for child bearing. Traditional visual examination methods can be adapted to determine the sex of the human remains. This method may not provide 100% accurate result as it depends entirely on the expertise of the examiner. The introduction of metric methods may provide accurate results in the sex determination of human skeletal remains. <sup>(2)</sup>

According to Gray's Anatomy, <sup>(3)</sup> the hip bone is irregular in shape and presents a constricted central part which carries a cup-shaped depression, the acetabulum, on the outer surface. The bone is expanded above and below the acetabulum, and exhibits an oval or triangular obturator foramen below and in front of the acetabulum. The hip bone consists of one dorsal component, the ilium and two ventral components, the ischium and the pubis. The three components join at the acetabulum which is separated initially

by a triradiate cartilage and the latter is then replaced by bone. The acetabulum articulates with the head of femur to form the hip joint.

The present study has been planned to measure the length, width and weight of 100 adult dry hip bones. The coxal index has also been calculated. These indicators may significantly help in differentiating the sex of human hip bones which may be of great help to anatomists, forensic experts and anthropologists.

Measurements taken on both right and left sided bones indicate that there is bilateral asymmetry in hip bones. Similar studies have been conducted in different races. The present study will hence provide valuable information about the Indian population.

## MATERIALS AND METHODS

A total of 100 Indian adult unpaired right and left dry hip bones were studied from the teaching collection of department of Anatomy, Yenepoya medical college, Mangalore. Of the 100 bones studied, 50 were male and 50 were female hip bones. 50 bones belonged to right side and 50 to left side. All the hip bones selected showed normal anatomical features. Specimens showing osteoarthritic changes, evidence of any previous trauma or skeletal disorders, presence of any prosthesis and pediatric sized bones were excluded from the study. The parameters measured were length, width and weight of hip bone. The measurements were taken using an osteometric board and a weighing machine. Three readings were taken for each parameter and the average was recorded. All measurements were carried out with the same instrument throughout the study.

### Length of hip bone

The length was measured from the most superior point on the iliac crest to a plane drawn along the inferior surface of ischium. The measurement was taken using an osteometric board and the length was recorded in cms. The most superior point of

the iliac crest was placed along the fixed side of the board and the inferior surface of ischium along the movable arm. (Figure-1)

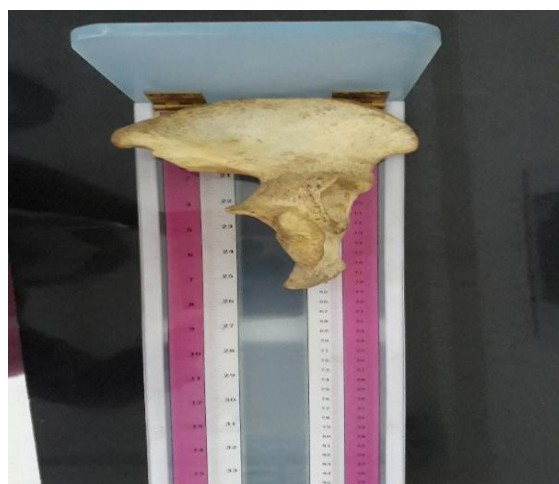


Figure-I- Photograph showing measurement of length of hip bone using an osteometric board

### Width of hip bone

The maximum distance from the anterior iliac spine to posterior iliac spine was considered as the width of hip bone. The measurement was taken using an osteometric board and the length was recorded in cms. The posterior superior iliac spine was kept in contact with the fixed side of the board and anterior superior iliac spine along the movable arm. (Figure-II)



Figure-II- Photograph showing measurement of width of hip bone using an osteometric board

### Weight of hip bone

The weight of each hip bone was measured using an electronic weighing

machine and the weight was recorded in grams. (Figure-III)



Figure-III- Photograph showing measurement of weight of hip bone

### Coxal index

Coxal index was calculated using the formula- width of hip bone/ length of hip bone \* 100

The gender and laterality of the bones were determined using conventional methods listed below:

### Determination of gender

Male hip bones showed prominent muscular markings, thick and everted ischio-pubic rami, large acetabular cavity,

large and oval obturator foramen and scarcely visible pre auricular sulcus.

Female hip bones showed less prominent muscular markings, thin and inverted ischio pubic rami, small acetabular cavity, triangular obturator foramen and predominantly visible pre auricular sulcus.

### Determination of laterality

The acetabulum is directed laterally

Ilium forms upper part of the bone that lies above the acetabulum

The obturator foramen lies below the acetabulum

### Statistical Methods

Range, mean, median, standard deviation and standard error of mean were determined for each parameter. All values were compared with series of other workers to draw the conclusion.

### RESULTS

Length, width and weight of all 100 hip bones were noted down. Coxal index was also calculated. The parameters were compared based on laterality and gender. Range, mean, median, standard deviation and standard error of mean were calculated for each parameter.

TABLE- 1: COMPARISON OF MORPHOMETRICAL PARAMETERS OF HIP BONE IN TERMS OF LATERALITY

		LENGTH (CMS)	WIDTH (CMS)	WEIGHT (GMS)	COXAL INDEX
MEAN	RIGHT	18.06	12.73	103.96	70.71
	LEFT	18.07	13.09	109.84	72.45
	TOTAL	18.07	12.91	106.9	71.58
MEDIAN	RIGHT	18.2	12.8	94	70.11
	LEFT	18	13.1	103	72.58
	TOTAL	18.1	12.95	98.5	71.35
SD	RIGHT	0.974	0.93	33.134	5.016
	LEFT	1.194	1.04	34.018	3.96
	TOTAL	1.084	0.985	33.576	4.49
SEM	RIGHT	0.138	0.132	4.69	0.71
	LEFT	0.169	0.147	4.81	0.56
	TOTAL	0.154	0.140	4.75	0.64
RANGE	RIGHT	15-20.5	10.2-14.6	46-232	59.3-81.82
	LEFT	16-21.5	10.5-15.5	42-202	62.79-80
	TOTAL	15-21.5	10.2-15.5	42-232	59.3-81.82

SD- Standard deviation, SEM- Standard error of mean, CMS- Centimeters, GMS- Grams

According to Table-1, the length of hip bone varied from 15-20.5 cms on the right side and 16-21.5 cms on the left side. Width varied from 10.2-14.6 cms on the right side and 10.5-15.5 cms on left side. Weight varied from 46-232 grams on right

side and 46-202 grams on left side. Coxal index varied from 59.3-81.82 on right side and 62.79-80 on left side. The mean of all parameters were more on the left side compared to the right sided hip bones. Median of all parameters were more on left

side except length which was slightly higher on the right side. Standard deviation and standard error of mean were more on left

side for all parameters except for coxal index which was more on right side.

**TABLE- 2: COMPARISON OF MORPHOMETRICAL PARAMETERS OF HIP BONE IN TERMS OF GENDER**

		LENGTH (CMS)	WIDTH (CMS)	WEIGHT (GMS)	COXAL INDEX
MEAN	MALE	18.57	13.15	114.88	70.91
	FEMALE	18.33	12.55	93.8	68.69
	TOTAL	18.45	12.85	104.34	69.8
MEDIAN	MALE	18.5	13	107	70.29
	FEMALE	18.4	12.5	93	68.50
	TOTAL	18.45	12.75	100	69.40
SD	MALE	1.191	0.99	30.11	4.45
	FEMALE	1.53	0.83	25.22	4.99
	TOTAL	1.36	0.91	27.67	4.72
SEM	MALE	0.17	0.14	4.26	0.63
	FEMALE	0.22	0.12	3.57	0.71
	TOTAL	0.20	0.13	3.92	0.67
RANGE	MALE	16-21.5	10.5-15.2	70-198	61.76-81.93
	FEMALE	16-27	10.2-14.8	46-172	54.81-78.79
	TOTAL	16-21.5	10.2-15.2	46-198	54.81-81.93

SD- Standard deviation, SEM- Standard error of mean, CMS- Centimeters, GMS- Grams

Table-2 shows the comparison of morphometrical parameters of hip bone according to gender. The length of hip bone varied from 16-21.5 cms in males and 16-27cms in females. Width varied from 10.5-15.2 cms in males and 10.2-14.8 cms in females. Weight varied from 70-198 grams in males and 46-172 grams in females. Coxal index varied from 61.76-81.93 cms in

males and 54.81-78.79 in females. The mean and median of all parameters were more in male hip bones compared to the female bones. Standard deviation was more in male bones for all parameters except for coxal index which was more in female hip bones. Standard error of mean was more in male bones for all parameters except for length which was more in female hip bones.

**TABLE-3: DISTRIBUTION OF WEIGHT OF HIP BONE IN TERMS OF LATERALITY & GENDER**

WEIGHT (GMS)	RIGHT HIP BONES		LEFT HIP BONES		MALE HIP BONES		FEMALE HIP BONES	
	Number	%	Number	%	Number	%	Number	%
40-89.9	16	32	14	28	10	20	23	46
90-139.9	26	52	28	56	30	60	23	46
140-189.9	07	14	06	12	08	16	04	8
190-239.9	01	2	02	4	02	4	0	0

Table-3 shows the distribution of weight of hip bones in terms of laterality & gender. Maximum number of bones ranged from 90-139.9 grams.

**TABLE-4: DISTRIBUTION OF LENGTH OF HIP BONE IN TERMS OF LATERALITY & GENDER**

LENGTH (CMS)	RIGHT HIP BONES		LEFT HIP BONES		MALE HIP BONES		FEMALE HIP BONES	
	Number	%	Number	%	Number	%	Number	%
15-16.9	06	12	08	16	04	8	05	10
17-18.9	36	72	32	64	30	60	32	64
19-20.9	08	16	8	16	13	26	12	24
21-27	0	0	02	4	03	6	01	2

Table-4 shows the distribution of length of hip bones in terms of laterality & gender. Maximum number of bones belonged to the range of 17-18.9 cms.

**TABLE-5: DISTRIBUTION OF WIDTH OF HIP BONE IN TERMS OF LATERALITY & GENDER**

WIDTH (CMS)	RIGHT HIP BONES		LEFT HIP BONES		MALE HIP BONES		FEMALE HIP BONES	
	Number	%	Number	%	Number	%	Number	%
10-11.5	05	10	03	6	03	6	04	8
11.6-13	29	58	22	44	24	48	36	72
13.1-14.5	15	30	22	44	20	40	09	18
14.6-16	01	2	03	6	03	6	01	2



Table-5 shows the distribution of width of hip bones in terms of laterality & gender. Maximum numbers of bones were present in the range from 11.6-13cms.

**TABLE-6: DISTRIBUTION OF COXAL INDEX OF HIP BONE IN TERMS OF LATERALITY & GENDER**

COXAL INDEX	RIGHT HIP BONES		LEFT HIP BONES		MALE HIP BONES		FEMALE HIP BONES	
	Number	%	Number	%	Number	%	Number	%
54-60.99	1	2	0	0	0	0	03	6
61-67.99	16	32	05	10	13	26	19	38
68-74.99	24	48	30	60	27	54	22	44
75- 81.99	09	18	15	30	10	20	06	12

Table-6 shows the distribution of coxal index of hip bone in terms of laterality & gender. Maximum number of bones ranged from 68-74.99.

## DISCUSSION

The knowledge of normal anatomical features and the morphology and morphometry of the acetabulum are prerequisites for complete understanding of the mechanics of hip joint. Any deviations of the parameters from normal range have strong correlation with the development of various kind of pathologies related to hip bone. The study of the parameters in male and female hip bones may be of great help for forensic experts and anthropologists. As race, climate, heredity and geographical areas have strong influence over the anthropometric parameters of the bone, the present study was undertaken to note the morphometrical parameters of hip bone in south Indian cadaveric hip bones. <sup>(4)</sup>

Weight of hip bone- According to the present study, the mean weight of hip bone in male was 114.88 and in female was 93.8 grams. According to the study done by Pullana et al, <sup>(5)</sup> the mean weight of hip bone in male was 121.72 grams and in female was 86.48 grams. Singh et al <sup>(6)</sup> had done a study on right and left sided hip bones. The mean weight in right sided hip bone was 136.71 grams and in left side was 124.82 grams. According to the present study, the mean weight of hip bone in right side was 103.96 and in left side was 109.84 grams. The findings in the present study were different from the past studies. According to Kalpana Purohit, Ankita Purohit et al, <sup>(7)</sup> mean weight in males right hip bone was 138.5g and in left, was 142g, whereas in

female right hip bone, mean was 110g and in left was 138g. These values are high when compared to present study.

Length of hip bone- In the present study, the mean length of hip bone in male was 18.57 cms and in female bone was 18.33 cms. According to the study done by Pullana et al, <sup>(5)</sup> the mean length of hip bone in male was 20.29 cms and in female was 18.31 cms. The mean length of hip bone was more in males in both the studies. According to the study done by Verneau et al, <sup>(8)</sup> the mean length in male bones was 22.0cm and in female bones was 19.7cm. In the study done by Maruyama et al <sup>(9)</sup> the mean length in male bones was 22.0cm whereas in female bones was 20.0cm. The mean length of hip bone was more in males in all these studies.

In the present study, the mean length of hip bone in right sided bone was 18.06 cms and in left sided bone was 18.07 cms. According to the study done by Singh et al, <sup>(6)</sup> the mean length of right sided hip bone was 19.77 cms and in left sided hip bone was 19.6 cms. The values noted by Lander <sup>(10)</sup> are 21.4 cm and 21.2 cm for right and left sided hip bones respectively.

Width of hip bone- According to the present study, the mean width of hip bone in male was 13.15 cms and in female hip bone was 12.55 cms. In the study done by Pullana et al, <sup>(5)</sup> the mean width in male hip bone was 14.38 cms and in female was 13.50 cms. The mean width of hip bone noted by Sudarshan Gupta Kiran Arora <sup>(11)</sup> was 13.73cms in males and 13.32 cms in female bones. The readings noted by Verneau <sup>(8)</sup> were 16.4 cm in males and 15.6 cm in females. Maruyama et al <sup>(9)</sup> noted that in males the width of the hip bone was 13.6 cm

and in females it was 13.1 cm. The mean width was more in male bones in all these studies.

The present study showed the mean width of right sided hip bone as 12.73 cms and that of left sided bones as 13.09 cms. According to Griffith<sup>(12)</sup> the reading on the left side was 15.24 cms and on right side was 14.48 cms. The readings are more on left side in both these studies. According to the study done by Singh et al,<sup>(6)</sup> the mean width of right sided hip bone was 14.14 cms and that of left sided hip bone was 13.86 cms.

Coxal index of hip bone- According to the present study, coxal index in male hip bone was 70.91 and in female bone was 68.69. According to the study done by Pullana et al,<sup>(5)</sup> the mean coxal index of hip bone in male was 70.87 and in female was 73.73. The values in male hip bones were similar in both the studies. According to the study done by Vijayeendrakannabur et al,<sup>(13)</sup> the mean value of coxal index was more in female bones than in male hip bones.

Singh et al<sup>(6)</sup> had done a study on right and left sided hip bones. The mean coxal index in right sided hip bone was 71.56 and in left side was 70.85. According to the present study, the mean coxal index of hip bone in right side was 70.71 and in left side was 72.45. The mean of coxal index was more in right side in the present study whereas it was more in the left side in the study done by Singh et al.<sup>(6)</sup>

## CONCLUSION

In the present study, all parameters showed higher values in male bones compared to female bones and left sided bones showed higher values compared to the right sided ones. Hence, these values can be used for sex determination of unknown skeletal remains. Studies done on hip bone may be of great help for Anatomists, anthropologists and orthopedic surgeons. It would be of great help to Forensic surgeons as well in solving medico legal cases. However, it should be kept in mind that the present study and the previous studies have

included small number of hip bones and though the results showed significant differences, it is worthwhile to perform similar further study with large number of bones from different age periods and from diverse population of the world.

**Acknowledgement:** None

**Conflict of Interest:** None

**Source of Funding:** None

## REFERENCES

1. Issac B. Biometry of the posterior border of the human hip bone: normal values and their use in sex determination. *J Anat Soc India* 2002; 51: 43-46.
2. Pal GP, Bose S, Choudhary S. Reliability of criteria used for sexing of hip bones. *J Anat Soc India* 2004; 53: 58-60.
3. Standring's Gray's Anatomy. 40th Ed, Edinburgh. Elsevier Churchill Livingstone Publishers; 2008.p, 1379-1380.
4. Msamati BC, Igbigbi PS, Layy CB. Geometric measurements of the acetabulum in adult Malawians: radiographic study. *East Afr Med J* 2003 ; 80: 546-549.
5. Bollavaram Pullanna, Bindhu S, Ramakrishna Avadhani, Meera Jacob. Morphometry of the adult human dry hip bone in south Indian population. *Int J Anat Res* 2019;7(1.2): 6178-6182.
6. Gursharan Singh Dhindsa et al. Morphometry of The Adult Human Dry Hip Bone, *Int J Pharm Pharm Sci.* 2013; 5(2):505-507.
7. Kalpana Purohit, Vipul Kant Singh, Kamil Khan, Ankita Purohit. Study of acetabular parameters of hip bone in north Indian population. *Indian journal of applied research* 2018;8:4.
8. Verneau, 1875. Cited by Thomson A in *J Anat Physiol* 1899; 33: 359-380.
9. Maruyama M, Feinberg JR, Capello WN, D'Antonio JA. Morphologic features of the acetabulum and femur. *Clin Orthop Relat Res* 2001; 393: 52-65.
10. Lander KF. The examination of a skeleton of known age, race, and sex. *J Anat* 1918; 52: 282-291.
11. Sudarshan Gupta Kiran Arora et al. study of significance of Total Pelvic Height and

- Pelvic Width in sex Determination of Human Innominate Bone in Gujarat Region GCSMC J Med Sci 2013;2(2).
12. Griffith WSA. Naegele pelvis. J Anat Physiol 1886; 21: 163-166.
13. Vijayeendranabur, Anita Deshpande. A Study of Sex Determination of Human Hip Bone by Total Pelvic Height and Coxal Index. National Journal of Basic Medical Sciences. 2019; 9(3): 115-120.
- How to cite this article: Meril Ann Soman, Nallathamby R. Morphometrical analysis of dry adult human hip bones by coxal index. *International Journal of Research and Review*. 2021; 8(7): 320-326. DOI: <https://doi.org/10.52403/ijrr.20210744>

\*\*\*\*\*