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Original Article

ROLE OF ILIUM IN SEXUAL DIMORPHISM OF HIP BONE: A MORPHOMETRIC STUDY IN NORTH INDIAN POPULATION

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ABSTRACT

Introduction: Sex estimation of skeletal remains is an important issue in both forensics and bioarchaeology. Many mammalian species display sexual dimorphism in the pelvis, where females possess larger dimensions of the obstetric canal than males. This is contrary to the general pattern of body size dimorphism, where males are larger than females. Pelvic dimorphism is often attributed to selection relating to parturition, or as a developmental consequence of secondary sexual differentiation. Current opinion regards the hip bone as the most reliable sex indicator because it is the most dimorphic bone, particularly in adult individuals.

Material & Methods: In the present study, an attempt has been made to find the base line data of thirteen parameters pertaining to ilia of 100 hip bones of known sex and side. Variables studied were: Total length of iliac crest, lengths of its ventral & dorsal segments; distance between Anterior Superior Iliac Spine & Iliac Tubercle; Iliac height; Ventral, Sacral, Direct, Lower & Upper iliac heights; Iliac breadth; Lower, Ventral & Sacral iliac breadths, Length of pelvic & sacral parts of Chilotic Line.

Results: The results obtained were tabulated, statistically analysed & compared to the earlier literature. It was seen that almost all the parameters except Sacral Iliac Height, Lower Iliac Height & Pelvic parts of Chilotic line were longer in males.

Conclusion: To conclude, the morphometry of ilium also constitutes an important mean of sexual dimorphism. However its parameters are longer in males as it does not form a part of birth canal so is independent of sex hormones & is akin to general rule that male bones are larger than female bones.

KEYWORDS : Sexual dimorphism, Hip bone, Ilium, sex determination, North Indian.

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INTRODUCTION

In skeletal remains, the sex determination by forensic anthropologists or bio archaeologists typically relies on the analysis of quantitative and qualitative characteristics of the skeleton. In this regard, the most widely used features belong to the pelvic and cranial areas [1]. The nature and degree of sexual differentiation in the pelvis has long been of interest to anatomists and anthropologists. It is of practical importance to of skeleton, in case of pelvic girdle, additional sex differentiating features are considered because of the reproductive functions mainly influenced by the sex hormones [4].

It is rather impossible to determine the sex of an individual from his skeletal remains unless all the bones are available. Excepting hip bone probably no other bone is as valuable in this regard [5]. Hip bone is an ideal bone for sex determination because it not only reflects the general sex differences between the two sexes but also the special adaptation of female hip bone for child bearing[6]. Moreover, of all the parts of the post cranial skeleton which are so important for the sex diagnosis of prehistoric skeleton remains, one of the two hip bones is usually sufficiently well preserved. This may give an insight into the particular significance which attaches to the hip bone in the assessment of sex classification [7].

It is widely recognized that skeletal characteristics vary among populations, thus each group should have specific standards to optimize the accuracy of identification [8]. The objective of this study is to determine the extent of dimorphism exhibited by the ilium of hip bones in order to examine their utility in the metric determination of sex in skeletal remains of North Indian origin. The parameters studied excluded those pertaining to anterior & posterior borders of hip bone.

MATERIALS AND METHODS

The material for the present study comprised of 100 hip bones of the known sex [Male:Female=80:20] and side [Right: Left=50:50], belonging to 40 male and 10 female individuals, obtained from the Department of Anatomy, Government Medical College, Amritsar, Punjab, India; during the period 2007-2009. The bones were undamaged and showed no pathological changes.

For each of the hip bones, the thirteen variables pertaining to the ilium were measured (Table 1; Fig 1 & 2).

For measuring these variables the following instruments were used:

1. Vernier callipers of the company Aerospace with a least count of 0.02 mm.
2. Ruler with a least count 1mm.
3. Doctor's tape.

Fig. 1: Diagram showing various ilial parameters taken from the gluteal surface of ilium. (Points have been discussed in Table 1)

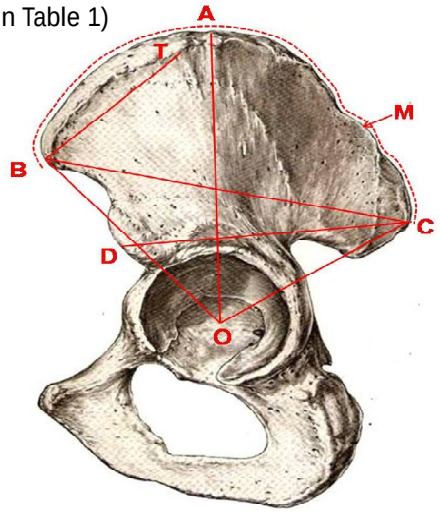


Fig. 2: Diagram showing various ilial parameters taken from the iliac (internal) & sacropelvic surfaces of ilium. (Points have been discussed in Table I)

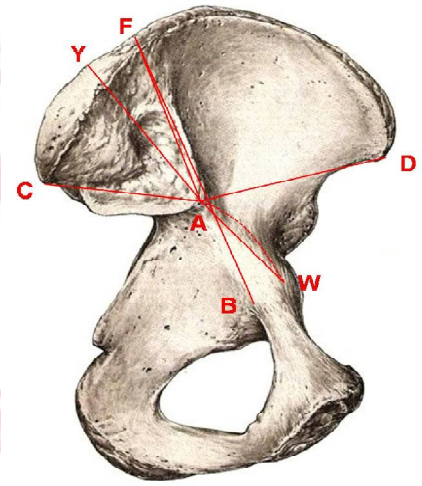


Table 1: Showing Different Parameters Of The Ilium Of The Hip Bone & Landmarks For Their Measurements.

Sr. no.	Parameter	Landmarks	Shown in fig. as
1	Total length of iliac crest	Arch ASIS-PSIS	Dotted BC (Fig. I)
1(a).	Length of ventral segment	Arch ASIS- Point M	Dotted BM (Fig. I)
1(b).	Length of dorsal segment	Arch Point M-PSIS	Dotted MC (Fig. I)
2	Distance Anterior superior iliac spine & Iliac Tubercle	ASIS- IT	BT (Fig. I)
3	Iliac height	Point O- Point A	OA (Fig. I)
4	Ventral iliac height	Point O- ASIS	OB (Fig. I)
5	Sacral iliac height	Point O-PSIS	OC (Fig. I)
6	Iliac breadth	ASIS-PSIS	BC (Fig. I)
7	Lower iliac breadth	AIIS-PSIS	CD (Fig. I)
8	Ventral iliac breadth	Point A- ASIS	AD (Fig.II)
9	Sacral iliac breadth	Point A- PSIS	AC (Fig.II)
10	Direct iliac height	IIP- Point F	BF (Fig.II)
11.s	Lower iliac height	Arch Point A- IP	Dotted AW (Fig.II)
12	Upper iliac height	Point A- Point F	AF (Fig.II)
13 (a).	Length of Pelvic part of chilotic line	Point A- IP	AW(thick) (Fig.II)
13(b).	Length of Sacral part of chilotic line	Point A- Point Y	AY(Fig.II)

ASIS- Anterior superior iliac spine, **PSIS**- Posterior superior Iliac Spine, **Point M**- Junction of ventral & dorsal segments on iliac crest, **IT**- Iliac Tubercle, **Point O**- Central point of acetabulum, **Point A**- Auricular Point, **AIIS**- Anterior inferior iliac spine, **IIP**- Ilioischiopubic tubercle, **Point F:** iliac crest at the limit of attachment of ilio-lumbar ligament, **IP**- Iliopubic eminence, **Point Y**- projection of pelvic part of chilotic line on iliac crest

The linear measurements were taken with the help of sliding Vernier calipers by keeping the caliper ends between the designated points (Photograph 1).

To measure the curved distances, doctor's tape and ruler were used e.g. to measure the length of the iliac crest extending between anterior superior iliac spine and the posterior superior iliac spine (Arch ASIS-PSIS [Sr. No. 1]), doctor's tape was plastered against the iliac crest. Then the tape was marked at the designated points (i.e. ASIS & PSIS), lifted off the bone and measured along the scale of the ruler. Other arches were measured in a similar way (Photograph 2).

Photograph 1: Illustrates measurement of straight Distances. (eg: Distance ASIS-IT, Sr No. 2)

Photograph 2: Illustrates measurement of curved distances (eg: total length of Iliac Crest; Sr. No. 1)

For measuring the **lengths of ventral & dorsal segments** of the iliac crest {Sr. No. 1(a) & 1(b)}, a point M was taken on the iliac crest at the junction of these two segments & then each of the two segments were measured.

To record **Iliac Height, Ventral iliac Height & Sacral iliac height** (Sr. No3,.4 & 5), central Point of Acetabulum (Point O in Fig. 1) was located. For locating the central point of acetabulum, Schultz (1949) [9] described following methods:

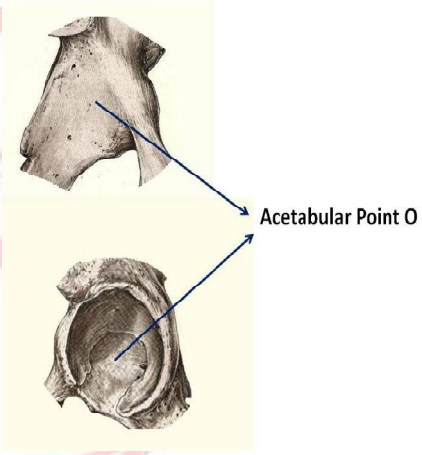
a) Frequently there is an irregularity both in the acetabulum and inside the pelvis.

b) There is a change in thickness which may be seen by holding the bone upto the light.

c) Often there is a notch in the border of the articular surface in the acetabulum.

In the present study method (a) of Schultz (1949) [9] was used (Fig. 3).

Fig. 3: Showing Acetabular Point.



For measuring **Ventral Iliac Breadth, Sacral Iliac Breadth**, (Sr. Nos 8 & 9) auricular point (Point A in Fig. II) was determined**.** The auricular point is the point of intersection of the arcuate line with the anterior border of the auricular surfaces

Direct Iliac Height (Sr. No. 10) was measured between ilio-ischio pubic tubercle and iliac crest at attachment of ilio lumber ligament (BF in Fig. II) with the help of vernier callipers on both sides. Ilio-ischio pubic tubercle is the aster like site of union of the pelvic elements which leaves, throughout life, a central tubercle, perhaps subdivided, and faintly prominent ridges marking the union of ilium with ischium and with pubis. The pubic union is crossed by iliopectineal line which continues upto or near the auricular surface [10].

Lower Iliac Height (Sr. No.11) is the distance along the ilio-pectineal line or its projection backwards, from auricular surface to ilio pubic junction on ilio pectineal line [10] (Dotted AW in Fig. II). It was taken with the help of a doctor's tape.

Upper Iliac height (Sr. No. 12) is the distance between the point where the iliopectineal line or its projection meets the auricular surface i.e. the auricular point and iliac crest at the limit of attachment of ilio-lumbar ligament [10] (AF in Fig. II). It was taken with the help of vernier calliper on both sides.

Chilotic line extends from iliopectineal eminence to the nearest point on anterior auricular margin {which corresponds to *auricular point* of Seidler (1980) [7]} and thence to iliac crest. The auricular point divides this chilotic line into anterior (pelvic) and posterior (sacral) segments [11]. For measurement of chilotic line and its segments, Derry (1923) [11] suggested marking puboiliac and auricular points. According to him the puboiliac point is located on the iliopectineal line at the site of original union of the pubis and ilium. Sometimes it is ill defined and then the iliopectineal eminence is a useful landmark in that case. The different segments were measured as follows:

(a) Pelvic Part: - It is the distance between the pubo iliac point and the auricular point (AW thick in Fig. II). It was recorded with the help of vernier callipers on both sides.

(b) Sacral part: - For determination of the sacral part of chilotic line, its pelvic part was extended upwards to meet the iliac crest and the point where it meets the same is marked. Then this was measured with the vernier callipers as the distance between the auricular point to the point marked on iliac crest vide supra (AY in Fig. 2).

Apart from these, 16 parameters of anterior border & 7 parameters of Greater Sciatic Notch were also observed [12, 13].

The entire data thus obtained was statistically analyzed using maximum and minimum values, range, mean, standard deviation and 95% confidence intervals of the mean. The total sample was then subdivided into two subsamples, the 20 females and 80 males respectively. The existence of significant differences between the means for the two subsamples was analyzed by using the Independent Student's t-test. Then the entire sample was subdivided according to side, i.e. 40 right males, 40 left males, 10 right females and 10 left females and analyzed by the Paired Student's t-test, i.e. male right bones were compared with male left bones and female right bones with the female left bones.

RESULTS AND TABLES

The observations of the thirteen parameters pertaining to ilium of the hip bone have been depicted in Table 2, which shows the mean values and range on right & left sides in males and females and also the mean values and range in the two sexes, irrespective of the sides. The p-values between the mean values of the two sides and two sexes have also been given in the table.

1. **Total Length of Iliac crest**: It was found to be significantly more in the North Indian males as compared to females (p-value = 0.001), but the difference in relation to side was insignificant (p-value = 0.259 in males & 0.181 in females), being more towards left in males and towards right side in females.
   - Length of ventral segment: It was significantly more in males (p-value = 0.001) as compared with females but difference with respect to side was insignificant in both sexes (p-value = 0.326 in males & 0.799 in females), being more on right side in males and on left side in females.
   - Length of dorsal segment: It was also more in males, the mean difference being statistically insignificant both with respect to sex (p-value = 0.123) and side (p-value = 0.088 in males & 0.141in females), being more on left side in males and on right side in females.
2. **Distance between Anterior Superior Iliac spine & Iliac Tubercle (ASIS-IIT).** Its Although being slightly more on left side in both the sexes, the difference between the sides was statistically insignificant (p-value = 0.084 in males & 0.382 in females). At the same time it was more in males as compared to females and the difference between the means with respect to sex was statistically highly significant (p-value = 0.001).
3. **Iliac height:** It was found to be slightly more towards left side in both the sexes but the difference between the sides was statistically

Sr. No.	Parameter (All values in cm)	MALES			FEMALES			P-value between Right & Left Sides		Mean values of 2 sexes
		Right Mean±S.D. (Range) [40]	Left Mean±S.D. (Range) [40]	Mean±S.D (Range) [80]	Right Mean±S.D. (Range) [10]	Left Mean±S.D (Range) [10]	Mean±S.D. (Range) [20]	Males	Females	
1	Total length of iliac crest	24.17±1.88 (20.90-28.70)	24.32±1.71 (21.50-27.90)	24.24±1.78 (21.65-27.60)	22.67±2.04 (20.20-25.40)	22.59±1.79 (20.40-25.50)	22.63±1.85 (20.30-25.45)	0.259	0.181	0.001
1(a).	Length of ventral segment	16.12±1.57 (13.20-18.70)	15.94±1.43 (13.0-19.0)	16.03±1.49 (13.60-18.50)	14.65±1.09 (13.60-17.90)	15.03±1.30 (13.90-17.90)	14.84±1.18 (13.85–17.45)	0.326	0.799	0.001
1(b).	Length of dorsal segment	8.05±1.23 (5.60-10.50)	8.36±1.29 (5.90-10.80)	8.20±1.26 (5.75-10.50)	7.96±1.55 (5.10-10.50)	7.44±1.09 (5.20-9.0)	7.70±1.24 (6.05-9.65)	0.088	0.141	0.123
2	Distance Anterior Superior Iliac Spine & Iliac Tubercle	6.25±0.80 (4.62–7.71)	6.46±1.01 (4.83-8.31)	6.35±0.83 (4.85-7.89)	5.44±0.82 (4.10-6.83)	5.68±0.70 (4.64-7.03)	5.56±0.76 (4.70-6.58)	0.084	0.382	<0.001
3	Iliac height	12.54±0.98 (9.06-14.80)	12.75±1.39 (7.98–16.90)	12.65±1.19 (8.52-15.10)	11.78±1.05 (10.52-13.80)	11.88±1.04 (10.61-13.81)	11.83±1.02 (10.57-13.81)	0.082	0.545	0.006
4	Ventral iliac height	8.60±0.69 (7.65-9.95)	8.43±0.73 (6.95-9.52)	8.52±0.71 (7.45-9.67)	8.02±1.55 (5.10-10.50)	7.73±0.59 (6.83-8.68)	7.88±0.58 (7.14-8.67)	0.038	0.176	<0.001
5	Sacral iliac height	9.73±1.05 (8.32-13.96)	9.75±0.91 (8.41-12.20)	9.74±0.98 (7.25-12.25)	9.75±1.07 (8.05-11.50)	10.03±0.97 (8.69-11.58)	9.80±0.94 (8.57–11.50)	0.882	0.09	0.819
6	Iliac breadth	14.48±1.19 (12.60-17.00)	14.59±1.16 (10.60-16.90)	14.53±1.16 (10.60-16.90)	14.37±1.49 (12.29-17.30)	14.27±1.59 (12.71-17.70)	14.32±1.50 (12.50-17.50)	0.057	0.459	0.496
7	Lower iliac breadth	12.57±0.96 (9.71-14.40)	12.59±0.97 (9.95-14.50)	12.57±0.96 (9.71-14.40)	12.21±0.61 (11.29-13.60)	12.40±0.65 (11.22-13.43)	12.31±0.61 (11.26-13.52)	0.601	0.096	0.235
8	Ventral iliac breadth	8.89±0.72 (7.20-10.00)	8.93±0.71 (7.48-10.06)	8.88±0.68 (7.38-9.99)	8.67±0.65 (7.74–9.90)	8.76±0.68 (7.72-10.02)	8.72±0.59 (8.00-9.96)	0.642	0.629	0.273
9	Sacral iliac breadth	6.05±0.90 (4.99-8.07)	5.98±0.83 (4.57-7.70)	6.01±0.82 (4.87-7.80)	5.68±0.36 (5.30-6.30)	5.37±0.37 (4.52-5.80)	5.53±0.31 (4.94-6.02)	0.432	0.067	0.015
10	Direct iliac height	12.41±0.90 (10.70-14.80)	12.56±0.94 (11.35–15.10)	12.54±0.89 (11.25-14.95)	11.73±1.17 (9.95-13.40)	11.60±1.47 (8.01-13.25)	11.66±1.27 (8.95-13.28)	0.077	0.632	0.001
11	Lower iliac height	5.93±0.60 (4.80-7.71)	5.92±0.58 (4.90-7.60)	5.93±0.56 (4.85-7.66)	6.20±1.09 (4.70-8.60)	6.57±0.82 (5.40-8.40)	6.39±0.92 (5.05-8.50)	0.908	0.067	0.008
12	Upper iliac height	7.38±0.92 (6.16-10.02)	7.47±0.93 (6.04-9.97)	7.43±0.90 (6.39-10.00)	6.80±0.52 (6.10-7.64)	6.49±0.73 (5.50-7.79)	6.65±0.6 (5.80-7.68)	0.18	0.023	0.001
13(a).	Length of Pelvic part of chilotic line	5.43±0.64 (4.23-7.02)	5.48±0.65 (3.96-6.90)	5.46±0.60 (4.10-6.93)	5.74±0.79 (4.43-7.04)	6.07±0.82 (4.52-7.10)	5.91±0.73 (5.02-7.07)	0.528	0.141	0.009
13(b).	Length of Sacral part of Chilotic Line	6.82±0.81 (5.81-9.21)	6.85±0.91 (5.80-9.61)	6.83±0.84 (5.83-9.41)	6.18±0.46 (5.33–6.75)	5.98±0.73 (4.75-7.00)	6.08±0.54 (5.28-6.88)	0.596	0.283	0

insignificant in both sexes (p-value = 0.082 in males & 0.545 in females).However iliac height was significantly more in males (p-value = 0.006).

4. **Ventral Iliac Height:** It was more on right side in both the sexes, but the difference was statistically significant only in males (p-value = 0.038 in males & 0.176 in females). When compared between the two sexes the mean difference was highly significant (p-value < 0.001), being more in males as compared to females.
5. **Sacral iliac height:** It was more on left side in both sexes, though statistically insignificant (p-value = 0.882 in males & 0.090 in females). Similarly, on comparing the mean values of the two sexes, it was more in females on both the sides though the difference was statistically insignificant (p-value = 0.819).
6. **Iliac Breadth:** Although it was more towards left side in males & right side in females, the difference was statistically insignificant in both cases (p-value = 0.057 in males & 0.459 in females). The mean values were more in males, but the difference between the two sexes was also statistically insignificant. (p-value = 0.496).
7. **Lower iliac breadth:** In the present study, it was more in males as compared to females but the difference was statistically insignificant (p-value =0.235). Also it was more on right side in both sexes but the difference was again insignificant (p-value = 0.601 in males & 0.096 in females).
8. **Ventral iliac breadth**: In the North Indian

Population, ventral Iliac Breadth was more in males but the difference was statistically insignificant (p-value = 0.273). Similarly when compared on the two sides, it was more towards left side in both sexes but the difference was statistically insignificant (p-value = 0.642 in males & 0.629 in females).

9. **Sacral iliac breadth:** It was more in males as compared with females, the difference being statistically significant (p-value = 0.015). Also when compared between the two sides, although it was more towards the right side in both the sexes, the difference was statistically insignificant in both sexes (p-value = 0.432 in males & 0.067 in females).
10. **Direct iliac height:** It was found to be significantly more in males (p-value =0.001). Also it was more towards left side in males and towards right side in females but the differences were statistically insignificant in both sexes (p-value = 0.077 in males & 0.632 in females).
11. **Lower iliac height:** It was found to be significantly more in females (p-value = 0.008). But on comparison between the sides, although being more towards right side in males and left side in females, the differences were statistically insignificant in both (p-value = 0.908 in males & 0.067 in females).
12. **Upper Iliac Height:** It was more in males as compared with females, the difference between means being highly significant (p-value = 0.001). When compared with respect to sides, it was more towards left side in males but on right side in females. However, the difference was significant only in females (p-value = 0.180 in males & 0.023 in females).
13. **Chilotic Line**:

a. **Length of pelvic part of chilotic line:** The pelvic part was significantly longer in females (p-value = 0.009). Also it was longer towards left side in both the sexes but the difference was statistically insignificant (p-value = 0.528 in males & 0.141 in females).

b. **Length of sacral part of chilotic line**: The sacral part was significantly longer in males (p-value = 0.001). However, it was insignificantly longer towards left side in males (p-value = 0.596) & towards right side in females (p-value = 0.283).

Authors	Race	Iliac Height (cm)		Iliac Breadth (cm)	
		Males	Females	Males	Females
Straus (1927) [10]	Whites	13.02	12.44	16.24	15.73
Straus (1927) [10]	Negroes	12.5	11.65	15.66	14.12
Davivongs (1963) [4]	Australian Aborigines	19.76	18.19	14.8	14.22
Orban (1980) [19]	French & Belgian	13.42	12.62	15.85	15.31
Patriquin et al (2005) [8]	Whites	-	-	16.32	16.1
Patriquin et al (2005) [8]	Blacks	-	-	15.01	14.54
Rissech & Malgosa (2005) [17]	Lisbon	-	-	15.47	15.28
Rissech & Malgosa (2005) [17]	Iberian	13.02	12.21	-	-
Rissech & Malgosa (2005) [17]	Britannic	12.66	11.5	-	-
Present Study	North Indians	12.65	11.83	14.46	14.32

Table 3: Comparison Of Iliac Height And Iliac Breadth.

Table 4: Comparison Of Direct Iliac Height, Lower Iliac Height & Upper Iliac Height.

Authors	Race	Direct Iliac Height (cm)		Lower Iliac Height (cm)		Upper Iliac Height (cm)	
		Males	Females	Males	Females	Males	Females
Straus (1927) [10]	Whites	13.02	12.44	5.25	5.97	8.09	7.05
Straus (1927) [10]	Negroes	12.5	11.65	5.07	5.61	7.86	6.77
Hanna & Washburn (1953) [20]	Eskimoes	-	-	5.45	6.18	7.24	6.42
Present Study	North Indians	12.54	11.66	5.93	6.69	7.43	6.65

Table 5: Comparison Of Pelvic And Sacral Parts Of Chilotic Line.

Authors	Race	Pelvic Part (cm)		Sacral Part (cm)	
		Males	Females	Males	Females
Davivongs (1963) [4]	Australian Aborigines	4.99	5.82	6.4	5.67
Present Study	North Indians	5.46	5.91	6.83	6.08

DISCUSSION

Jordaan (1976) [14] is of the view that the hominid pelvis represents the total response to the diverse forces which have moulded its structure, these being requirements for efficient bipedalism and parturition. The pelvic girdle, a purely endochondral structure shows marked changes with ascent through the phyla. The changes occurring in the ilium are greater than those in ischium and pubis, because the structure is more closely related to different modes and needs for locomotion. The essential features which characterize the gradient of changes are the closer relationship between the vertebral column and the ilium, which ensures stability for weight bearing, and its development to provide more advantageous leverage for the muscles concerned in locomotion. Robinson (1972) [15] pointed out that these changes serve the additional purpose of moving the body's centre of gravity downwards and backwards.

The mammalian ilium is primitively a long, slender rod triangular in cross-section; but in heavy bodied ungulates and bipeds (man) in which there are powerful gluteal muscles, the base is much expanded. The transition from the quadrupedal to the permanent erect posture brought about a significant shortening of the ilium [14].

1. Total length of iliac crest: It has been earlier studied only by Joshi et al (2007) [16] who found it to be longer in females, but our study has revealed contrasting results as in our sample iliac crest was significantly longer in males as compared to females (Table 2). However no significant differences with respect to side were found.

Also as is evident from Table 2, in the present sample, both the ventral and dorsal segments of crest were longer in males than in females. This finding is partially in consonance & partially contrary to results of Joshi et al (2007) [16] who encountered the dorsal segment to be longer in males but the ventral segment to be distinctly larger in females.

2. Distance between Anterior Superior Iliac spine & Iliac Tubercle (ASIS-IT): It has been studied only by Joshi et al (2007) [16] in Ahmednagar population and was found to be 4.0 cm in males & 3.94 cm in females. These values are much lower than our values indicating a regional variation. However in both the studies, this distance is more in males owing to robusticity of male skeleton and to the fact that this distance is independent of influence of female hormones.

3. Iliac Height: Table 3 compares the mean values of iliac height in the two sexes as seen in the present study with the earlier studies. It is evident from this table that iliac height in both male and female North Indians is almost comparable to Negroes [10] & Britannic [17] races, but less than the others. However in all these races ilium is longer in males as compared to females. The same was true in the present study with the difference between the means of the two sexes being highly significant (p-value = 0.006).

Rissech & Malgosa (2005) [17] , in their study on Iliac growth patterns, threw light upon the fact that from 16-19 years onwards, differences in iliac height between the sexes were significant, consequent upon the growth spurt at this age.

Phylogeny: Jordaan (1976) [14] pointed out that there occurs a significant shortening of ilium as we ascend in phylogeny from Chimpanzee to Gorilla to Orang to Human. This is brought about by the transition from the quadrupedal to a permanent erect posture. On the other hand Hooton (1930) [18] regarded the human pelvis as so specialized and so distinct from that of anthropoid apes that he found it impossible to derive man from ancestral stock of Chimpanzee-Gorilla-Orang type. Schultz (1949) [9] regarded the comparative shortness of human ilium as representing a primitive condition in which man equals the macaque and has preserved this condition rather than he first participated in the trend of anthropoids towards increased length of ilium followed by its shortening.

4. Ventral Iliac Height: Earlier only Orban (1980) [19] had measured it in French & Belgian and found it to be 9.47 cm & 9.08 cm in males and females respectively. Thus ventral iliac height is more in French and Belgian as compared with North Indian population (See Table 2) indicating a racial difference. However in both the studies; males have got more ventral iliac height as

compared to females and in the present study the difference between the means of the two sexes was highly significant (p-value = 0.000).

5. Sacral Iliac Height: In the only early study by Orban (1980) [19] on French & Belgian races, it was found to be 10.32 cm in males & 10.43 cm in females, again more than our values of 9.74 & 9.80 in the two sexes of the present study. Here it is pertinent to note that in contrast to the earlier parameters, sacral iliac height was longer in females as compared with males in both the studies.

6. Iliac Breadth: A look at Table 3 shows that the Iliac breadth in the present study is less than almost all the earlier studies except in females of Australian Aborigines [4] in whom it is slightly less than the present study. Also in consonance with all the earlier studies, it is more in males as compared to females. But on statistical evaluation, the difference was found to be insignificant (p-value = 0.496). While Davivongs (1963) [4] laid stress on its significance in sex determination, Rissech & Malgosa (2005) [17] denied it.

7. Lower Iliac Breadth: In the present study the lower iliac breadth was found be more in males as compared to females and also more on left side as compared to right . However none of the differences was statistically significant.

8. Ventral Iliac Breadth: In the present study this parameter was more in males, the difference between the means for both sexes being statistically insignificant (p-value = 0.273). However when compared on the two sides, it was more towards left side in both sexes but the difference was statistically insignificant in both sexes (p-value = 0.642 in males & 0.629 in females). No other study could be traced in the accessible literature to compare it.

9. Sacral Iliac Breadth: This parameter was more in males as compared with females, the difference being statistically significant (p-value = 0.015). Also when compared between the two sides, although it was more towards the right side in both the sexes, the difference was statistically insignificant in both sexes (p-value = 0.432 in males & 0.067 in females).

No previous studies are available for comparisons of Lower iliac breadth, Ventral Iliac Breadth & Sacral Iliac Breadth. However a higher value of Lower Iliac breadth, Ventral Iliac Breadth and Sacral Iliac Breadth in males, may be attributed to their robust skeleton and no contribution of these parameters to the formation of birth canal in females. No earlier data could be traced in accessible literature to compare these parameters.

10. Direct Iliac Height: As evident from Table 4, present values were in consonance with Negroes but are slightly less than Whites [10]. However the direct iliac height was more in males as compared to females in all the races and in the present study the difference between the means of the two sexes was highly significant (p-value = 0.001).

11. Lower Iliac Height: A glance at Table 4 shows that when compared between the two sexes the lower iliac height is more in females in all the races and amongst the races it is maximum in North Indians (both males and females). A higher value in females in all races may be attributed to the fact that it forms a part of pelvic inlet.

12. Upper Iliac Height: Table 4, shows that when compared between the two sexes, the Upper Iliac Height is always more in males in all races & amongst the races it is maximum in Whites [10] and minimum in Eskimos [20] **,** values of the present study being in between the two races (both males and females).

Straus (1927) [10] has aptly highlighted the fact that the most striking sex differences in ilium appear in relation to lower and upper segments of ilium i.e. the females of both White & Negro stocks exceed their respective male counterparts in lower iliac height with reverse results in upper iliac height. Same is true about the North Indians.

13. Length of Chilotic Line - Pelvic Part - Sacral Part, As can be seen in Table 5 our values are slightly higher than those of Davivongs (1963) [4], but in both the studies the pelvic part was found to be significantly longer in females while the reverse was true for the sacral part. This may be attributed to the fact that it is only the pelvic part of chilotic line which takes part in the formation of pelvic inlet and is hence longer in females; the sacral part being longer in males owing to male robusticity.

CONCLUSION

To summarize the present study compares morphometry of some of the ilial parameters between the two sexes & the two sides. The parameters with statistically significant differences between the two sexes were Total length of iliac crest, lengths of its ventral segments; distance between Anterior Superior Iliac Spine & Iliac Tubercle; Iliac height; Ventral, Direct, Lower & Upper iliac heights; Sacral iliac breadths, Length of pelvic & sacral parts of Chilotic Line.

It was also seen that almost all the parameters except sacral iliac height, lower iliac height & pelvic part of chilotic line were longer in males as compared to females owing to robusticity of the male skeleton and to the fact that ilium contributes least towards formation of birth canal. So it is smaller in females as compared with males obeying the general rule that male skeletons are larger & more robust because of stronger muscle mass. The three parameters i.e. Sacral Iliac Height, Lower Iliac Height & Pelvic parts of Chilotic line were longer in females as they contribute in formation of true pelvis & birth canal.

However no significant differences with respect to side could be made out except for Ventral Iliac breadth which was significantly more towards right side in males & Upper Iliac height which was significantly more towards right side in females.

Thus it can be laid forward that ilium of hip bone may also serve as an important indicator for sexual dimorphism. But owing to the scanty literature available for comparison, more elaborate studies are required for different populations. The present study provides a baseline data for this region.

Conflicts of Interests: **None**

REFERENCES

[1]. Mountrakis C, Eliopoulos C, Koilias CG & Manolis SK. Sex Determination using metatarsal osteometrics from the Athens collection. Forensic Sci Int 2010; 200(1-3): 178.

[2]. Washburn SL. Sex differences in the pubic bone. Am J Phys Anthropol 1948; (6): 199-207.

[3]. Hooton EA. From primate life cycle. In Up from the ape. 8th Edition, New York: The Macmillam Company; 1959: 106-120.

[4]. Davivongs V. The pelvic girdle of the Australian Aborigine; sex differences and sex determination. Am J Phys Anthropol 1963; 21: 443-56.

[5]. Singh S & Gangrade KC. The Sexing of Adult Clavicles Demarking points for Varanasi Zone. J Anat Soc Ind 1968; 17: 89-100.

[6]. Pal GP, Bose S and Choudhary S. Reliability of criteria used for sexing of hip bones. J Anat Soc Ind 2004; 53(2): 58-60

[7]. Seidler H. Sex-diagnosis of isolated os coxae by discriminant functions. J Human Evol 1980; 9: 597-600.

[8]. Patriquin ML, Steyn M, Loth SR. Metric analysis of sex differences in South African black and white pelves. Forensic Sci Int 2005; 147(2-3): 119-127.

[9]. Schultz AH. Sex differences in the pelves of primates. Am J Phys Anthropol 1949; 7: 401-424.

[10]. Straus WL Jr. The human ilium: Sex and Stock. Am J Phys Anthropol 1927; 11(1): 1-28.

[11]. Derry DE. On the sexual and racial characters of the human ilium. J Anat 1923; 58: 71-83.

[12]. Kalsey G, Singla RK & Sachdeva K. The role of the greater sciatic notch of the hip bone in sexual dimorphism: a morphometric study in the North Indian population.Med Sci Law 2011; April 51: 81-86.

[13]. Sachdeva K, Singla RK & Kalsey G. The role of the anterior border of the hip bone in sexual dimorphism: a morphometric study in the North Indian population. Med Sci Law 2011; October 51, 208-214.

[14]. Jordaan HVF. The differential development of the hominid pelvis. S Afr Med J 1976; 50: 744-748.

[15]. Robinson JT. Early Hominid Posture & Locomotion. Chicago: University of Chicago Press 1972. Cited By Jordaan HVF. The differential development of the hominid pelvis. S Afr Med J 1976; 50: 744-748.

[16]. Joshi SD, Joshi SS, Waghmgde PS, Daimi SR and Siddiqui AU. Metrical study of some parameters of hip bone. Abstract (Sr. No. 33) of paper presented in 55th National Conference of Anatomical society of India, 26th – 29th Dec 2007, p 74.

[17]. Rissech C and Malgosa A. Ilium growth study: applicability in sex and age diagnosis. Forensic Sci Int 2005; 147(2-3): 165-174.

[18]. Hooton EA. The Indians of Pecor Pueblo. Yale University Press, New Haven; 1930, Cited by Heyns OS. Sexual Differences in the Pelvis. S Afr J of Med Sci 1947; 12: 17-20.

[19]. Orban RS. An evaluation of the sexual dimorphism of the human innominate bone. J Human Evol 1980; 9: 601-607.

[20]. Hanna RE and Washburn SL. Determination of sex of skeletons, as illustrated by a study of the Eskimo pelvis. Human Biol 1953; 25: 21-27.

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