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SEXUAL DIMORPHISM OF FEMUR IN THE POPULATION OF ODISHA: AN ANTHROPOMETRIC OBSERVATIONAL STUDY

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ABSTRACT: Introduction: Femur is the key bone among the skeletal remains to determine sex for anatomists, anthropologists, and forensic experts. In the present study, we considered most of the parameters to determine sex from the femur. **Methods:** We studied eighty-four undamaged, intact femora of unknown sex. The present study was carried out in S. C. B. Medical College Cuttack from December 2019 to April 2020. The parameters, like maximum length, maximum breadth, head circumference, mid-shaft circumference, and vertical diameter femur head, were measured by a goniometer and verniers caliper. **Results:** From each femur above-mentioned parameters were recorded, and the details were obtained about the mean, Standard Deviation, percentage, and p-Value. Then these details were compared with the findings of other studies to conclude. **Conclusion:** These measurements show the values are higher in males than females and were statistically highly significant between males and females with a p-value <0.0001.

INTRODUCTION: The determination of sex is almost accurate from the examination of the entire skeleton. It is expected to determine sex from isolated long bones or its fragments in the medico-legal purpose¹. It is a challenge to determine sex from unidentified human skeletal remains for Anthropologists and Forensic investigators². Skull and pelvis are the most reliable bones for sex determination^{3, 4}. The femur is the human skeleton's largest, strongest, and heaviest bone^{5, 6}. As it takes more time to decay than the other bones, it becomes a better specimen for the sex determination of a human being.

The sexual dimorphism seen between the males and the females in Anthropometry of the body parts, including soft tissues and bones, was explained by Stanfield's Postulation of Evolutionary Biology (1977). He postulated that the genotypic variance is inversely proportional to the intensity of stabilizing selection in evolution. This will explain the difference in the morphology of adult human males and females.

As per Krogman⁷ the accuracy of the sex identification from the complete skeleton was 100 percent, skull with pelvis constituted 98 percent, pelvis alone 95 percent, skull alone 90 percent, and long bones 80 percent. He subsequently estimated to reduce the above figures by 5-10% depending upon the specimens available for sex determination. The above authors had worked on the sexual dimorphism of the bones by morphometry and statistical analysis.

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On standing femoral alignment is oblique, the shaft converges downwards and medially. Femoral oblique orientation approximates the feet, bringing them under the bodyweight line in standing or walking. It gives forward movements also. Women have greater femoral obliqueness due to greater pelvic breadth and shorter femora⁸. The femur bone is also used to evaluate stature and estimate sex¹⁶. The present work attempts to establish some of the parameters that will be of great help in sex determination both in Medico-legal and Anthropometric studies.

MATERIALS AND METHODS:

Source of Data: The present study was conducted on 84 adult human femora of unknown sex in the anatomy department of SCB Medical College, Cuttack, Odisha.

Inclusion Criteria: All the femora were free of damage or deformity and fully ossified, indicating adult bone.

Exclusion Criteria: Pathological changes like cortical bone deterioration, extreme osteophytes activity, osteoarthritis, and fracture *etc.*, were excluded from the study.

The Following Measurements were taken for Each Femur:

Maximum length: It was measured as the straight distance between the highest point of the head and the lowest point on the medial condyle. A femur was placed with its ventral side upwards on the osteometric board. The movable cross piece was touching the highest point of the head. Measurement was taken in centimeters.



Proximal Breadth: Proximal Breadth was measured as the distance from the most medially placed point on the head of the femur to the most

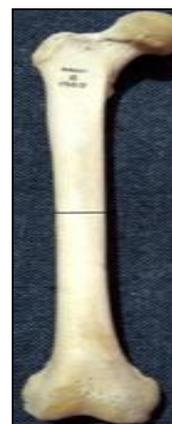
laterally placed point on the greater trochanter. Measurement was taken with the help of the Vernier caliper in centimeters.



Head Circumference: Circumference of the head was measured at the border of the articular surface of the femur head by measuring tape in centimeters.



Mid Shaft Circumference: Was measured by the circumference of the middle of the shaft of the femur with the help of measuring tape in centimeters.



Vertical Diameter of Head of Femur: It was measured as a distance between the highest and deepest point of the head lying in the equatorial plane of the head with the help of a Vernier caliper in centimeters.



Statistical Software: The statistical software, namely IBM SPSS statistics version 21 was used for the analysis of the data and Microsoft Word and Excel have been used to generate graphs, tables *etc.*

TABLE 1: MAXIMUM AND MINIMUM VALUE WITH STATISTICAL DATA OF ALL THE PARAMETERS STUDIED IN MALE FEMORA IN THE PRESENT STUDY

Parameters	Maximum cms	Minimum cms	Mean	S D	S E	P value
Length of femur	47.25	36.75	42.267	±2.590	0.386	<0.0001
Proximal breadth	9.2	7.0	8.058	±0.553	0.082	<0.0001
Mid shaft circumference	9.45	7.1	7.944	±0.614	0.092	<0.0001
Head circumference	15	11.6	13.296	±0.86	0.128	<0.0001
Head vertical diameter	4.7	3.1	4.152	±0.363	0.054	<0.0001

In the present study, the maximum, minimum femoral length with mean, standard deviation, and P-value in males were 47.25 cm, 36.75, 42.267, 2.590, 0.0001 respectively. The maximum, minimum proximal femoral breadth with mean, standard deviation, and P-value in males was observed as 9.2 cm, 7.1, 8.058, and 0.0001. In the mid-shaft circumference, the maximum, minimum length with mean, standard deviation, and P-value in males were 9.45 cm, 7.1, 7.944, 0.614, and

Observation: Observations were made in 84 dry, complete, undamaged human femora collected from the Anatomy Department, S.C.B. Medical College and Hospital, Cuttack, Odisha.

Each femur measurement was recorded in detail about the mean, Standard Deviation, percentage, and p-Value. The results were compared with the findings of other studies to conclude. The femora under observation were forty-five of male sex (23 from right sides and 22 from left side) and thirty-nine of female (18 from right side and 21 from left side).

0.0001 respectively. Further, we studied the maximum, minimum femoral head circumference with mean, standard deviation, and P-value in males was 15 cm, 11.6, 13.296, 0.86, and 0.0001. the maximum, minimum value of femoral vertical head diameters with mean, standard deviation, and P-value in males were 4.7 cm, 3.1, 4.152, 0.363, and 0.0001, respectively **Table 1**. Calculated P-Value showed that all parameters taken together were statistically highly significant with $p < 0.0001$.

TABLE 2: MAXIMUM AND MINIMUM VALUE WITH STATISTICAL DATA OF ALL THE PARAMETERS STUDIED IN FEMALE FEMORA IN THE PRESENT STUDY

Parameters	Maximum cms	Minimum cms	Mean	S D	S E	P-value
Length of femur	43.5	36.5	39.950	±1.932	0.390	<0.0001
Proximal breadth	8.25	6.4	7.244	±0.532	0.085	<0.0001
Mid shaft circumference	8	6.1	7.062	±0.456	0.073	<0.0001
Head circumference	13	10.7	12.023	±0.730	0.117	<0.0001
Head vertical diameter	4.05	3.3	3.723	±0.226	0.036	<0.0001

In the present study, the maximum, minimum femoral length with mean, standard deviation, and P-value for females were 43.5 cm, 36.5, 39.95, 1.932, and 0.0001. The maximum, minimum proximal femoral breadth with mean, standard deviation and P-value in females were observed as 8.25, 6.4, 7.244, 0.532, and 0.0001. Coming to the femur's mid-shaft circumference, the maximum, minimum value with mean, standard deviation, and P-value in females were 8 cm, 6.1, 7.062, 0.456 and 0.0001. Further, we studied the maximum,

minimum femoral head circumference with mean, standard deviation, and P-value in females was 13 cm, 10.7, 12.023, 0.73 and 0.0001.

The maximum, minimum value of femoral vertical head diameters with mean, standard deviation and P-value for females was 4.05 cm, 3.3, 3.723 0.226, and 0.0001, respectively **Table 2**.

Calculated p-Value showed that all parameters taken together were statistically highly significant with $p < 0.0001$.

DISCUSSION: The Sexual Dimorphism of the human bones, Davivong's (1963) has stated that as a general rule, the male bones are more massive and heavier than female bones. The crests, ridges, tuberosities, and lines of attachment of muscles and ligaments are more strongly marked in males. However, the femur remains by far the masterpiece of skeletal specimen in establishing sex. The study was conducted on 84 dry human femora of unknown sex. The value of different parameters for males and females with statistical significance was compared with other workers. In the discussion of every parameter, an attempt has been made in the present work to compare with the other workers simultaneously. Concerning certain parameters, it is not possible to give the comparative table with other workers due to the non-availability of the observation tables.

TABLE 3: COMPARISON OF MEAN OF MAXIMUM FEMORAL LENGTH IN MALE AND FEMALE: IN THE PRESENT STUDY

Population & Study	Male (in cm)	Female (in cm)
Kumari, R. D. K. V. P. ⁸	44.47	40.29
Ranjan <i>et al.</i> ⁹	47.04	42.72
Deepak S <i>et al.</i> ¹⁰	43.95	41.06
Panda M ¹¹	41.32	39.91
Takale S. ¹²	48.08	39.7
Purkait & Chandra, Indian ¹³	45.1	44.04
Present Study	42.2	39.5

The table above compares the mean of the maximum femoral length of males & females between the present study and other studies. The mean maximum femoral length value in the present study in males was 42.2cm. In other studies, it varies from 41.03 cm to 48.08 cm. The mean of Maximum femoral length in the present study was lower than the other studies and similar to Deepak S *et al.* Panda M ^{10, 11}. **Table 3** the comparison of the Maximum Length of females between the present study and other studies shows that the Mean Femoral Maximum Length in females in the present study was 39.5 cm. In other studies, it varies from 39.7-44.04 cm.

The mean of maximum femoral length in the female in the present study was lower than the authors cited in the above table. It was similar to the present value of Panda M from Odisha and Deepak S *et al.* **Table 4.**

TABLE 4: COMPARISON OF MEAN OF PROXIMAL BREADTH IN MALE AND FEMALE: IN THE PRESENT STUDY

Population of study	Male (in cm)	Female (in cm)
Kumari, R. D. K. V. P. ⁸	8.21	7.42
Ranjan <i>et al.</i> ⁹	8.6	7.5
Panda M ¹¹	7.61	7.21
Present Study	9.2	8.25

The comparison of the proximal breadth of male and female femur between the present study and other studies has been shown in the table. The Maximum proximal breadths in male femora were 9.2 cm. In other studies, it varies from 8.5-9.0 cm. The maximum proximal breadth of male femora in the present study was very similar to Ranjan *et al.* ⁹ the comparison of maximum proximal breadth in females between the present study and the other studies.

The Maximum proximal breadth in female femora was 8.25. In other studies, it varies from 8.1-9.0 cm, while the maximum proximal breadth in females in the present study was lower. The present study has a higher value than the Panda M ¹¹, and the sample from Ranjan *et al.* ⁹ was similar to the value **Table 5.**

TABLE 5: COMPARISON OF THE MEAN OF MIDSHAFT CIRCUMFERENCE OF MALES AND FEMALES: IN THE PRESENT STUDY

Population & study	Male (in cm)	Female (in cm)
Garji Soni <i>et al.</i> ¹⁴	7.96	7.34
Pavel Timonov <i>et al.</i> ¹⁵	9.3	8.3
Kalpana R <i>et al.</i> ¹⁶	8.3	7.4
Deepak S <i>et al.</i> ¹⁰	7.9	7.3
Present Study	7.9	7.0

The Comparison of Mid Shaft Circumference of males and females femur between in the present study and other studies has been shown in **Table 5.** The Mean Value of Mid Shaft Circumference in males in the present study was 7.9 cm. In other studies, it varies from 7.9 to 9.3 cm in males. The Mean Mid Shaft Circumference in the present study corresponds to the value seen in Deepak S *et al.* and Garji Soni *et al.*, India **Table 5.** The comparison of Mean Mid Shaft Circumference in females between the present study and other studies: The Mean Mid Shaft Circumference in females in the present study was 7.0 cm.

In other studies, it varies from 7.3 to 8.3 cm, while in the present study was similar to the value of Deepak S *et al.* and Garji Soni *et al.* **Table 6.**

TABLE 6: COMPARISON OF THE MEAN OF HEAD CIRCUMFERENCE IN MALES AND FEMALES IN CMS IN THE PRESENT STUDY

Population and Study	Male (in cm)	Female (in cm)
Deepak S <i>et al.</i> ¹⁰	13.66	12.28
Garji Soni <i>et al.</i> ¹⁴	13.66	12.28
Pavel Timonovetal ¹⁵	15.62	13.81
Kalpna R <i>et al.</i> ¹⁶	13.98	12.30
Present Study	13.29	12.02

Comparison of Head Circumference of males and females between the present study and other studies have been shown in the table. Mean Head Circumference in males in the present study was 13.29 cm and in the females was 12.02 cm. In other studies, it varies from 13.66 to 15.62 cm in the males and the females from 12.28 to 13.81 cm. The mean head circumference in the present study was lower than the Deepak S *et al.*¹⁶, Garji Soni *et al.*^{13, 16} and Kalpna R *et al.*¹. It corresponds with the value seen in Deepak S *et al.* and Garji Soni *et al.*, India **Table 7.**

The comparison of Mean Head Circumference in females between the present study and the other studies: The Mean Head Circumference in females in the present study was 12.02 cm. It varies from 12.28 to 13.81 cm in other studies, while the present study's mean of Head Circumference was lower than the Kalpna *et al.*, Garji Soni *et al.*, and Deepak S *et al.* **Table 7.**

TABLE 7: COMPARISON OF MEAN VERTICAL DIAMETER OF HEAD OF FEMORA FOR MALE AND FEMALE: IN THE PRESENT STUDY

Population and study	Male (in cm)	Females (in cm)
Kumari, R. D. K. V. P. ⁸	4.20	3.72
Ranjan <i>et al.</i> ⁹	4.38	3.83
Takale S. ¹²	4.6	4.18
Ruma Purkait <i>et al.</i> ¹³	4.42	3.83
Panda M ¹¹	2.93	2.71
Present study	4.15	3.72

The present study showed a statistically significant difference in the vertical diameter of the femur head between males and females. These findings correlated with Kumari, R. D. K. V. P.⁸, Ranjan *et al.*⁹, Takale S.¹² Ruma Purkait *et al.*¹³. The mean value of vertical head diameter was higher in males

than Females **Table 7.** Calculated p-Value showed that the difference in the mean head diameter in males and females was statistically highly significant with $p < 0.0001$. The mean value of vertical head diameter was higher in males than females. Calculated p-Value showed that the mean head diameter differences in males and females were statistically highly significant with ($p < 0.0001$) **Table 1 and 2.**

CONCLUSION: In the present study, we found that the femur length in the males was more than in the female. It ranges between 37-47 cm in males and 37-44 cm in females. The Vertical Diameter of the head in the males was more than the females. It ranges between 3.7 to 4.8 cm in the males and 3.3 to 4.1 cm in the females. The Proximal Breadth in the males was more than the females. It ranges between 7-9.3 cm in males and 6.4-8.4 cm in females. The Mid Shaft Circumference in males was more than the females. It ranges between 7.2 to 9 cm in males and 6.2 to 8 cm in females. The Head Circumference is also more in males than females. It ranges between 11.5 to 15 cm in males and 11 to 12.8 cm in females. These measurements show the values are more in males than the females. The value of the present study (Sexual Dimorphism of Femur) was statistically highly significant between males and females, *i.e.*, $p < 0.0001$. Hence, this study is important in medico-legal cases and has a role in reconstructive Orthopedic Surgery. This will also be helpful in the detection of sex by Anatomists and Forensic Experts.

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CONFLICT OF INTEREST: None to declare.

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