Sexual Dimorphism of Femoral Head - An Observational Study in the Population of Odisha

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ABSTRACT

BACKGROUND

Femur is the longest and strongest bone of the human body. It also takes relatively longer time to disintegrate after death, hence morphometric analysis of skeletal remains of femoral head can be considered for the determination of age and sex for forensic expert, anthropologist as well as anatomist. The present study was an attempt to establish sex of a skeleton by the help of femoral head diameters which will be of great help in medico-legal and anthropometric studies.

METHODS

The present study was carried out in the S C B Medical College Cuttack from May 2019 to June 2020 by taking 84 dried and intact femora. The vertical head diameter of femoral head and head circumference were measured by the vernier' s caliper and measuring tape in centimeters.

RESULTS

The result showed significant difference in the head circumference and the vertical diameter of head of femur of the male and female femora. It was found that the mean femoral head circumference of the male was 13.296 cm with a "S.D" of 0.8694 cm and female was 12.023 cm with a "S.D" of 0.73 cm and vertical diameter of male was 4.1520 cm with a "SD" of 0.3635 cm and that of female femora was 3.7231 cm with a "S.D" of 0.2264 cm respectively.

CONCLUSIONS

There was a significant difference in the head circumference and the vertical diameter of head of femur of the male and female femora which determines sexual dimorphism.

KEY WORDS

Anthropometry, Medico-Legal, and Standard Deviation (SD)

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BACKGROUND

Sex determination will be easy and accurate if the entire skeleton is available for examination but in the medico-legal cases, it is expected to determine sex from isolated long bones or its fragments.[1] The determination of sex from unidentified human skeletal remains is a challenge for anthropologists and forensic investigators.[2] Skull and pelvis are the most reliable bones for sex determination.[3,4] Femur is the largest, strongest and heaviest bone of the human skeleton.[5,6] As it takes more time to decay in comparison to the other bones, it is a better choice for 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), which says that the genotypic variance is inversely proportional to the intensity of stabilizing selection. This will explain the difference in the morphology of adult human males and females. The morphometric study of femoral head diameters for sexual dimorphism has been done by various anatomists and anthropologists from time to time Leelavathy et al. 2000, Asala et al. 1998, Trance et al. 1997. Most of them accepted that the femoral head diameters vary in relation to age, sex, genetic variations and different climatic conditions. Femoral head morphometry is helpful in forensic science and anatomy to determine sex of the skeleton. It is also helpful to orthopaedicians for replacement surgery.[7,8,9]

Sexual dimorphism of the femur has been very well studied in different populations with diverse and interesting results. Much work has been done earlier by various workers like Parson (1914),[10] Pons (1955),[11] Lofgren (1956),[3] Krogman (1986).[6] Thus, most of the long bones either individually or in combination have been subjected to statistical and morphological analysis for the purpose of determining sex.[11,12,13]

The above authors have worked on the sex determination of the bones using various statistical analyses. Determination of an individual sex from the available skeleton is of great importance in forensic medicine. In medico legal cases, determination of stature, sex and age from skeletal remains of deceased person is often referred to the anatomist and other professionals in the field of anthropology.[7,8,9] Sexual dimorphism of the femur has been very well studied in different population with diverse and interesting results. Thus most of the long bones either individually or in combination have been subjected to statistical and morphological analysis for the purpose of determining sex.[12]

Non metrical analysis to differentiate between male and female femora for the study is also used for head of femur which is larger and forms about two-third of sphere in male. It is smaller and forms less than two third of the sphere in females.

Linea Aspera is more prominent in male femur than in female femur and other general features include as male femur is larger, heavier, rough with prominent sites for muscular attachment. However, female femur is lighter with a smooth surface, and smaller with less prominent muscular attachment.

Aim

The present study was done in an attempt to establish femoral head parameters which will be of great help in sex determination both in medico-legal and anthropometric studies.

METHODS

The present observational study was conducted on 84 adult human femora (simple random sample) of unknown sex in the Department of Anatomy, S. C. B. Medical College, Cuttack, Odisha. Vertical diameter of the head of the femur 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 Vernier caliper in centimeters [Fig / Table 1]. Circumference of the head was measured at the border of the articular surface of the head of the femur by measuring tape in centimeters [Fig / Table 2].

Inclusion Criteria

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

Exclusion Criteria

Femur with any pathological changes (i.e. cortical bone deterioration, extreme osteophyte activity, osteoarthritis and fracture etc.) were excluded from the study.

Statistical Analysis

In the present study, the data obtained were analysed by Graph Pad Software and statistical significance was accepted when P value is ≤ 0.0001.

RESULTS

In the current study, 84 femoral head circumferences of unknown sex of adult femora were studied and the results are given below.

Sex	Male (n = 45)		Female (n = 39)	
Statistical data	Value of right femora (in cm) N = 23	Value of left femora (in cm) N = 22	Value of right femora (in cm) N = 18	Value of left femora (in cm) N = 21
Minimum value	11.5	11.7	10.7	10.7
Maximum value	15	15	13	13
Mean	13.317	11.872	13.272	12.152
Standard deviation	0.908	0.847	0.733	0.719

Table 1. The Maximum, Minimum and Mean Value with Standard Deviation of Head Circumference of Femora

This table showed that the minimum value of the head circumference of twenty-three male right femora was 11.5 cm while the maximum value was 15 cm and the mean value was 13.317 cm. The minimum value of the head circumference of the twenty-two male femora belonging to the left side was 11.7 cm while the maximum value was 15 cm and the mean was 11.872 cm. In female, the minimum value of the head circumference of the right femora was 10.7 cm and the maximum value was 13 cm with a mean of 13.272 cm.

The minimum value of the head circumference of the left side female femora was 10.7 cm, the maximum value was 13

cm and the mean value was 12.152 cm in [Table 1]. This table also showed the mean of the head circumference of twenty-three male right femora was 13.317 cm while the standard deviation was 0.908 cm. The mean of the head circumference of the twenty-two male femora belonging to the left side was 11.872 cm while the standard deviation was 0.847 cm. In the female, the mean of the head circumference of the right femora was 13.272 cm while the standard deviation was 0.733 cm. The mean of the head circumference of the left side female femora was 12.152 cm while the standard deviation was 0.719 cm.

Parameter	Sex	N	Mean	S / D	P Value
Head circumference (in cm)	Male	45	13.296	0.8694	≤0.0001
	Female	39	12.023	0.7300	

Table 2. Head Circumference of a Total Eighty-Four Male and Female Femora Studied with Their Mean S/D and S/E

S / D - Standard Deviation and S / E - Standard error, Cms - Centimetres

The results indicate that there was a significant difference in the head circumference of the male and female femora. Thus, it was found that the mean of the head circumference of the male was 13.296 cm with a standard deviation of 0.8694 cm was significantly different from the mean value of the head circumference of the female femora which was 12.023 cm with a standard deviation of 0.73 cm which was given in [Table 2]. In the present study, the vertical diameter of the head of femur was studied by Vernier's caliper and the results obtained were as follows.

Sex	Male (N = 45)		Female (N = 39)	
Side right and left	Value of right femora (in cm) N = 23	Value of left femora (in cm) N = 22	Value of right femora (in cm) N = 18	Value of left femora (in cm) N = 21
Minimum value	2.6	3.6	3.3	3.3
Maximum value	4.6	4.8	4.1	4
Mean	4.132	4.172	3.683	3.757
Standard deviation	0.427	0.291	0.214	0.235

Table 3. The Maximum, Minimum and Mean Value with Standard Deviation of Vertical Diameter of Head of Femur of Male and Female Femora in Centimetres

In total, eighty-four femora were taken, out of which forty-five were male and thirty-nine were female. Out of the forty-five male femora specimens, twenty-three belonged to the right side and twenty-two belonged to the left side. Similarly, out of the thirty-nine female femora specimen, eighteen belonged to the right side and twenty-one belonged to the left side. The minimum value of the vertical diameter of head of femur of twenty-three male right femora was 2.6 cm while the maximum value was 4.6 cm and the mean value was 4.132 cm.

The minimum value of the vertical diameter of head of femur of the twenty-two male femora belonging to the left side was 3.6 cm while the maximum value was 4.8 cm and the mean was 4.172 cm. In the female, the minimum value of the vertical diameter of head of femur of the right femora was 3.3 cm and the maximum value was 4.1 cm with a mean of 3.683 cm.

The minimum value of the vertical diameter of head of femur of the left side female femora was 3.3 cm, the maximum value was 4 cm and the mean value was 3.757 cm [Table 4]. This table also showed that the mean of the vertical diameter of head of femur of twenty-three male right femora was 4.132 cm while the standard deviation was 0.427 cm. The mean of the vertical diameter of the head of femur of the twenty-two male femora belonging to the left side was 4.172 cm while the standard deviation was 0.291 cm. In the female, the mean of the vertical diameter of head of femur of the right femora was 3.683 cm while the standard deviation was 0.214 cm. The mean of the vertical diameter of head of femur of the left side female femora was 3.757 cm while the standard deviation was 0.235 cm.

Parameter	Sex	N	Mean	Std. Dev.	P Value
Vertical diameter of head of femur (in cm)	Male	45	4.1520	0.3635	≤ 0.0001
	Female	39	3.7231	0.2264	

Table 4. Vertical Diameter of Head of Femur of Eighty-Four Male and Female Femora Studied with their Mean, S/D and S/E

Thus it was found that the mean of the vertical diameter of head of femur of the male was 4.1520 cm with a standard deviation of 0.3635 cm was significantly different from the mean value of the vertical diameter of head of femur of the female femora which was 3.7231 cm with a standard deviation of 0.2264 cm which is given in the table below.

DISCUSSION

In the present study, the maximum head circumference in male was 14.5 cm and female was 13 cm. The mean value of head circumference in males was 13.29 cm and female was 12.02 cm. The value was higher in males as compared to females. The P value in the head circumference in male and female was highly statistically significant with $P < 0.001$. The calculated range for right male was 11 – 15 cm, and for right female 10 – 13 cm. The left male femora between 11 – 15 cm and the left female femora was 10 – 13 cm. The standard deviation of male femora was 0.86 cm and the female femora was 0.73 cm [Fig / Table 5].

Population and Study	Male (In cm)	Female (In cm)
Deepak S et. Al.	13.66	12.28
Garji Soni et. Al. (India)	13.66	12.28
Pavel Timonovetal (Bulgaria)	15.62	13.81
Kalpana R et. Al. (India)	13.98	12.30
Present study	13.29	12.02

Table 5. Comparison of the Mean of Head Circumference in Male and Female in the Present Study

Comparison of head circumference of males and females between present study and other studies has been shown in the above table. Mean head circumference in males in present study was 13.29 cm and in the females was 12.02 cm. The mean head circumference in present study was slightly lower than the Deepak S et al.[13] Garji Soni et al.[14] and Kalpana R et al. [Table 5]. The mean vertical diameter of femoral head in the present study was found to be 4.15 cm in males and 3.72 cm in females which is almost similar to the study done by the authors was given in Table 6.

Population and Study	Male (In cm)	Females (In cm)
Rajendra Prasad et. Al. (1996)[15]	4.30	3.91
Asala (2001)[16]	4.84 (Whites) 4.45 (Blacks)	4.20 (Whites) 3.90 (Blacks)
Ruma Purkait et. Al. (2002)[17]	4.42	3.83
Chauhan et. Al. (2002)[18]	4.56	4.42
Present Study	4.15	3.72

Table 6. Comparative Study of Vertical Diameter of Head of Femur (in cms) in the Present Study

The present study showed a statistically significant difference in vertical diameter of head of femur between males and females. These findings correlated with that of Asala

(2001)[16] and Ruma Purkait et al. (2002)[17] and Rajendra Prasad et al. (1996).[15] The present study showed that the vertical head diameter of right male femur varied from 3.0 to 5.0 cm and of right female femur varied from 3.0 to 4.0 cm. Mean value of vertical head diameter was higher in male as compared to female. Calculated P - value showed that the difference in the mean head diameter in male and female was statistically highly significant with $P < 0.001$ [Table 5]. The vertical head diameter of left male femora varied from 3.6 cm to 4.8 cm and of left female femora varied from 3.4 cm to 4.0 cm [Table 6]. The mean value of vertical head diameter was higher in males as compared to females. Calculated P value showed that differences in the mean head diameter in male and female was statistically highly significant with $P < 0.0001$ [Table - 2 & Table - 4].

CONCLUSIONS

The vertical diameter of the head in males was more than females. It ranges between 3.7 to 4.8 cm in the males and 3.3 to 4.1 cm in the 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 that the values are more in males than the females. The value of the present study (Sexual Dimorphism of Femur) was statistically highly significant between male and female i.e. $P < 0.0001$ [Table - 2 & Table - 4]. Femoral head morphometry is considered vital when skeletal fragments are obtained for forensic evaluation of sex. It is also helpful to anthropologist and anatomist for sex determination in research works.

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