Research article

A comparative study of sex determination using femoral parametersRajeev Kumar Kanchan¹, Pritika Dutta², Shankar Gupta³¹Assistant Professor, Department of Anatomy, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India²PhD Scholar, All India Institute of Medical Sciences, New Delhi, India³Assistant Professor, Department of Physiology, Madhubani Medical College, Madhubani, Bihar India

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Corresponding author: **Shankar Gupta**. Email: mr.shankar.gupta@gmail.com**ABSTRACT**

Introduction and Aim: Extensive examination of the femoral anthropometry has been commonly accepted to disclose sexual differentiation. The current study was carried out to evaluate various measurements of the pathologically fit femora of the unknown sex to differentiate the sex of the femora.

Materials and Methods: Each femur was meticulously assessed and analyzed for six specific parameters such as maximal length, proximal breadth, and head circumference, mid-shaft circumference, vertical diameter, and neck-shaft angle of the femur bone. All the measurements were statistically analyzed and tabulated.

Results: The results were highly significant to all the parameters thereby concluding that an individual's sex can be determined by examining the femora.

Conclusion: The results leave a huge scope for validation over a larger sample size focussing on an extensive human race.

Keyword: Maximal length; proximal breadth; head circumference; mid-shaft circumference; vertical diameter; neck-shaft angle.

INTRODUCTION

Determination or verification of an individual's sex is considered to be of substantial significance in the field of forensic medicine. It is relatively simple if one has the access to the entire skeletal remains for examination. For decades, the determination of sex from unidentified human skeletal remnants has remained to be a tough challenge for anthropologists and forensic investigators. In medico-legal cases, it is expected to differentiate age, build and sex from isolated, fragmented bones and is often referred to professional anatomists or anthropologists (1).

Over the past couple of years, several researchers have tried to establish gender differentiation from the remains of a skeleton as precisely as possible. Pelvic bone, remains of mastoid, mandibles and that of the craniofacial area have become quite popular choices (2). Even though the skull and pelvis are regarded as the most reliable bones of the human being, the precision level to determine sex through the remnants of the skull and pelvis are limited to ninety-eight per cent. The chances of the skull and pelvis to determine sex separately are only 90% and 80% respectively (3).

Japan had conducted a study to diagnose sex through a series of long bones. Humeral width, radial diameter, ulnar articular breadth, femoral transverse diameter and the epiphyseal breadth of tibia proved to be a good indicator for sexual diagnosis of the skeleton (4). For a long time, several scientists have focussed their attention on the femur as it is regarded as the largest,

sturdiest and heaviest bone of the human skeletal system and therefore takes the longest time to decay compared to the other bones of the human skeleton. However, very few studies regarding the femur have been reported from Asian sub-continent like India (5). Sex biologists have long ago recognized that gender differentiation is dependent on several specific determinants like diet, heredity, population type and density, geographic location and climatic condition (6). As vast a country like India that bears a huge population, a study of the femur through morphological methodologies such as observation seems unreliable as it is solely dependent upon the observer's visual ability and experience.

Hence, employing metric analysis for sex differentiation is the most practical technique as it is easier, and eliminates any possibility of human bias or subjective variations (7).

In recent years, anatomists have carried out multiple measurements to differentiate and verify the sex of either the known or the unknown femora. The femur extends from the hip to the knee and constitutes the head, neck, greater trochanters and lesser trochanters proximally. The hip joint is formed when the head of the femur articulates with the acetabulum of the hip bone. The lower ends of the femur articulate with the tibia and forms the knee joint. On standing, the femora become oblique with the shaft converging downwards and medially. Femoral obliquity estimates the feet of the bearer, thus approximating it with the body weight in standing or during walking. This accords forward movements of the legs with increased speed, clarity

and smoothness. Due to short stature and greater pelvic breadth, the femoral obliquity is much greater in females as compared to males. Appropriate examination of the femora has the potential to provide important information such as identification of the racial or cultural background, a judgment of build and sex determination (8). The present study aims to find out the sex determination between male and female femora and to study the accuracy of various parameters and measurements in identifying the sex of the femur.

MATERIALS AND METHODS

The present observational study was conducted on 84 adult human femora of unknown sex in the Department of Anatomy, SCB Medical College, Cuttack, Odisha for a duration of six months from March 2018 to August 2018. The draft was consented to by Institutes' Ethics Committee before the commencement of the study (IEC No. – 601/26.02.18).

Inclusion criteria involved femora that were free of damage or deformity and was fully ossified thereby indicating adult bone. A femur that had any pathological alterations like fractures, osteoporosis, osteoarthritis, bone cancer and cortical bone deterioration were excluded. Following are the instruments that were used for the measurements - osteometric board, Vernier calliper, flexible measuring tape, protractor, divider, digital camera, marker pens and thread.

Six parameters were observed from each dry and undamaged human femora:

Maximum length of the femora

It was calculated as the straight distance along the articular cartilage boundary from the most superior point on the femoral head to the most inferior point on the medial condyle (proximal medial part that receives the adductor magnus tendon). The measurements were reported in centimeters while the femur was positioned on the osteometric board facing its ventral side upward.

Proximal breadth of the femur

It was calculated as the distance from the most medially positioned point on the head of the femur to the most laterally positioned point on the greater trochanter, a quadrilateral protuberance from the junction of the neck and shaft. Measurement was taken in centimeters with the help of Vernier callipers.

Head circumference of the femur bone

The circumference of the head was measured at the border of the articular surface of the head of the femur, represented as an area that is broad like an inverted v, for the positioning of the patella and tibia. The head circumference was quantified by a measuring tape in centimetres.

Mid-shaft circumference of the femora

The shaft is characterized as long, slender and tubular. Its middle one-third area features three surfaces and borders. The mid-shaft circumference is the measure of the circumference of the middle of the shaft of the femur, estimated with the help of measuring tape in centimetres.

Vertical diameter of the head of the femur

The head of the femora is described as the rounded ball-like surface and is almost spherical. The medial side of the femoral head presents a depression namely the fovea that is attached to the ligamentum teres femoris. The head of the femur is connected to the shaft through the neck. The vertical diameter of the femoral head is the measurement between the highest and deepest point of the head lying in the equatorial plane of the head, evaluated with the help of a Vernier callipers in centimetres.

Neck shaft angle of the femora

The neck of the femora is narrowest in the mid-region and widest laterally, and is connected to the head of the femora at an angle of 127 degrees that is known as the angle of inclination or commonly termed as the neck-shaft angle. This angle diminishes gradually from the time of birth up to the age of 10 and is usually smaller in size in females. The neck-shaft angle is the one that facilitates the unhindered movement of the hip joint. It is measured as the obtuse angle between the long axis of the femoral neck and the long axis of the proximal part of the femoral shaft. The axis of the neck is determined using a thread that divides the anterior surface of the neck into two halves. The axis of the shaft is determined by a thread that extends in the mid-sagittal plane over the anterior surface of the bone of the upper end of the femur. Measurement was taken with the help of a protractor in degrees.

After the completion of data curation, the observed data were analysed with the help of statistical software namely IBM SPSS version 2. Graphs and tables were created using Microsoft Word and Microsoft Excel.

RESULTS

Observations were made in 84 dry and intact human femora collected from the Department of Anatomy, S.C.B. Medical College and Hospital. From each femur, the above-mentioned data were recorded and the details were obtained about the mean, percentage, p-value. Figure 1a depicts that out of the total eighty-four femora that were taken, forty-five were male and thirty-nine were female. Out of forty-five male femora specimen, 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 length of twenty-three male right femora was 36.0 cm while the

maximum value was 48.0 cm and the mean value was 42.086. The minimum value of the length of the twenty-two male femora belonging to the left side was 37.5 cm while the maximum value was 46.5 cm and the mean was 42.454 cm. In the female, the minimum value of the length of the right femora was 37.0 cm and the maximum value was 44.0 cm with a mean of 39.5 cm. The minimum value of the length of the left side female femora was 36.0 cm, the maximum value was 43.0 cm and the mean value was 39.666 cm.

Levene's test for equality of variance was conducted to analyse the statistical significance of maximal length between the male and female femora. Thus it was found that the maximum length of the femora in males was significantly different from that of females (p-value 0.000). Fig. 1b shows the maximum length of male femora is mostly within the range of 42.5-44.5 cm constituting 31.11%, followed by 40.5-42.5 cm constituting 22.22%. The maximum length of femora of the female is mostly in the range of 38.5-40.5 cm constituting 38.46%, followed by 40.5-42.5 cm constituting 25.64%. Similarly, figure 2a shows the mean value of the minimum and maximum proximal

breadth of the male and female femora (p-value 0.000). Fig. 2b exhibits the difference between the male and female femoral proximal breadth in terms of centimetres and percentage. Equivalent to the above results, it has been seen that there is a statistical significance of head circumference (fig. 3a), the vertical diameter of the head (fig. 4a), mid-shaft circumference (fig. 5a) and neck-shaft angle (fig. 6a) when compared with gender, wherein males showed a significant increase in the above-mentioned parameters of femora as and when compared to females (p-value 0.000). The second part of all the figures expresses the percentage range in male and female femora with respect to head circumference, the vertical diameter of the head, mid-shaft circumference and neck-shaft angle (fig. 3b, 4b, 5b and 6b) respectively.

The mean maximum femoral length value in the present study in males is 42.2 cm and that of females is 39.5 cm. when compared with other international studies, it has been noted that these values vary from 42.9 cm to 47.7 cm and from 39.7 to 44.3 cm in males and females respectively.

Fig. 1: Maximum length of male and female femora (a) measurement in cm (b) measurement in percentage

Fig. 2: Proximal breadth of male and female femora (a) measurement in cm (b) measurement in percentage

Fig. 3: Head circumference of male and female femora (a) measurement in cm (b) Measurement in percentage

Fig. 4: Mid shaft circumference of male and female femora (a) measurement in cm (b) measurement in percentage

Fig. 5: Vertical diameter of male and female femora (a) measurement in cm (b) measurement in percentage

Fig. 6: Neck shaft angle of male and female femora (a) measurement in cm (b) measurements in percentage

DISCUSSION

The mean of maximum femoral length in the present study was lower than that of the Nigerians and south African blacks, and much lower as compared to the South African whites (9-11). When compared with additional Indian studies, it is to be noted that the range of value of the femoral length in the present study is lesser than those studies conducted in southern parts of India and Maharashtra (7, 12, 13). The maximum proximal breadths of the right male femora were 9.3 cm and the left male femora were 7 cm. Previous studies have featured the values to be in a range of 8.5-9.0 cm. The maximum proximal breadth of male femora in the present study was very similar to Ziylan (14). Similarly, the mean head circumference in males in the present study was 13.29 cm and in females was 12.02 cm. It has been established that the mean head circumference in the present study corresponds well with the values seen by Howale *et al.*, and Soni *et al.*, (15, 3). Similar findings have been recorded with that of the mid-shaft circumference wherein the present study corresponds well with the previous studies conducted in India (15, 3).

In the present study, the mean vertical diameter of the head of the femur was found to be 4.15 cm in males and 3.72 cm in females. Asala studied femora in Africa showed the average vertical diameter of the head of the femur to be 4.84 cm in white males and 4.23 cm in white females (10). Likewise, a study conducted on the south Indian cadavers has reported the values to be lower than that of the present study (7). Our study has depicted the mean neck shaft angle in males as 125.9° and females as 125.7°. An extensive study was done taking over 8000 femur bones and representing about 100 groups of human taking variables like age, sex, climatic conditions and lifestyle modifications wherein they have concluded that neck-shaft angle seems to be on an ascending trend as the economy transits from rural to urban zones and a descending trend as the working lifestyle shifts from mobile to sedentary habits (16).

CONCLUSION

The current study does indicate that there is gigantic sexual differentiation between males and females when compared with the variable parameters of the femora, thereby resulting in immense practical and applied utility in medico-legal cases. The results leave a huge scope for validation over a larger sample size focussing on an extensive human race.

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CONFLICT OF INTEREST

All the authors hereby claim that there is no conflict of interest.

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