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ORIGINAL ARTICLE

Study of anthropometric parameters of adult human femora.

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ABSTRACT… Objective: To study the variations in anthropometric parameters of the adult human femora including total length, shaft length, the angle anteversion and neck shaft angle in femur of Pakistani origin. **Study Design:** Descriptive Correlational. **Setting:** Department of Anatomy, Rawalpindi Medical University. **Period:** April, 2022 to June, 2022. **Material & Methods:** Eighty femora of undetermined gender and age were selected from the bone bank of Anatomy Department, Rawalpindi Medical University (RMU). Measuring tape was used to measure length and goniometer was used to measure angles. **Results:** Thirty five bones were of right side and 45 of the left. The total femur length was 43.75±3.01 cm and the femur shaft length were 30.21±2.54 cm. There was no significant difference between the two sides. The mean neck shaft angle was 128.79±5.05 degrees with no difference between the sides. The mean angle of anteversion was 16.43±5.14 degrees with a significantly greater angle on the right compared to the left side (p=0.028). **Conclusion:** In Pakistani Femur there is no significant difference in the total, shaft lengths and neck shaft angles on the right and left sides. This bilateral symmetry shows synchronization which is important for posture and movement. However, the Angle of Femoral Neck Anteversion is significantly greater on the right as compared to the left. Also, this angle is less than reported in African and more than reported in American and European population.

Key words: Anatomy, Bone Density, Femur, Hip Joint, Multiple Trauma, Orthopedics, Population.

INTRODUCTION

The femur, being the longest and strongest bone in the body, forms the thigh region. Anatomically, it can be divided into 3 parts: a round proximal, articular head along with its neck; a cylindrical femoral shaft; and a substantial, wider, distal extremity presenting double condyles which articulate with tibia. The spherical head articulates at the acetabulum to form the hip joint. The neck is a medial extension of the shaft of the femur and makes an angle with it. The femoral shaft is convex forward and comprises of 3 surfaces (anterior, lateral, and medial) and 3 borders (medial, lateral, and posterior). The posterior border is marked by a narrow ridge: having medial and lateral lips called linea aspera. The nutrient foramina, which contains the nutrient artery to supply the whole bone, lies in close association to the linea aspera. The distal femoral end is formed of two condyles, i.e., lateral and medial, which are separated posteriorly by the intercondylar fossa.[1]

Different angles of the femur can be used to describe its morphology. The neck-shaft angle (NSA) is the angle of intersection between the axes of the neck and the shaft of the femur.

The NSA or angle of inclination are also known as Collo-diaphyseal angle (CDA) of femur. This angle exists due to the presence of slight obliquity of the shaft from the straight longitudinal axis and marked angular inclination of the neck from the shaft. It has found immense clinical importance in orthopedics. The most frequently applied measure of hip anatomy is femoral neck-shaft angle.[2] Angle of inclination is defined as the angle subtended at the femoral shaft by the medially placed femoral neck. It can also be referred to as the neck-shaft angle. Its value ranges between 125°-135°. This angle enables movement at the hip

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joint. The neck–shaft angle is found to be widest at birth, gradually reducing until the age of 10 years (Birkenmaier et al 2010); it is found to be smaller in females. Clinically, it has found implications in the diagnosis of various pathological conditions of the hip and femur from Perthes disease, femoroacetabular impingement (FAI), femoral head necrosis (FHN), epiphysiolysis capitis femoris (ECF) to the disorders like osteogenesis imperfecta (OI), and proximal femoral fractures.[3] Special pre- and postoperative measurements of anthropometric parameters of NSA are required for surgical interventions such as hip replacement surgery, internal fracture fixation and osteotomies.

Angle of Femoral Neck Anteversion (FNA) is the angle between the transverse axis of the two condyles and the longitudinal axis passing through the femoral head and neck, depicting lateral rotation of the neck in the coronal plane.[4] It is also known as angle of torsion, caused by the medial rotation of the lower limb during the intrauterine life of the fetus. It is greater at a younger age and starts to decrease in adolescence. Additionally, there are certain conditions e.g., cerebral palsy that causes impaired movement resulting in less prominent or complete absence of decrease in FNA with age. Studies have shown that it is greatly influenced by the mechanical loading of the lower extremities. Everyday physical activity that includes putting force on the femur results in its increase.[5] Furthermore, femoral neck Bone Density increases with the angle of anteversion. Researchers have also found that infants facing the issue of hip dislocation during the parturition have higher values of the FNA. The neck is rotated laterally with respect to the shaft at some 10–15°, variations may exist at populations and individuals' level.[1]

Total length of femur bone is the distance between the uppermost point of the femoral head and the lowest point of the condyles of femoral bone. The growth of total length of femur is influenced by mechanical and hormonal factors. Studies have supported that applying a compressional force on the femora causes the inhibition of the femoral length growth and hence results in decreased total length of femora.[6] Total length has its value in determining the location of nutrient foramen on the femur. Femoral shaft length refers to the length of the shaft only. It can be defined as the distance between the point of the lowermost margin of the lesser trochanter and the uppermost part of the condyles. It is one of the important physical parameters of the femur.[1] Femoral bowing in women is a common complaint in the older age. Researchers have examined and reported that with age different changes in femur's shaft morphology causes increased risk of bowing of femur.[7]

The study of the morphological features of the femur will aid forensic anthropologists in race and gender determination, orthopedic surgeons in treatment of femur and hip joint related disorders and occupational therapists in developing prosthetics.

Limited studies are available on the anthropometric parameters of human femora in the Pakistani population. Therefore, the aim of this research was to study the variations in anthropometric parameters of the adult human femora including total length, shaft length, and the angle anteversion and neck shaft angle in femur of Pakistani origin.

MATERIAL & METHODS

A total of 100 femoral bones from the Pakistani population were collected from the bone bank of Rawalpindi Medical University (RMU), Pakistan, out of which 80 bones of undetermined gender and age were selected, which were anatomically sound and the rest of 20 bones were excluded which were having pathological variations or having any broken parts. The study was conducted from the time period of 3rd April, 2022 to 7th June, 2022. The study design was descriptive correlational. Before the commencement of research, ethical permission was taken from the Ethical Review Board, Rawalian Student Research Society, Rawalpindi Medical University (Ref No S-1-48-22, Dated 24-09-2022)

The total length of each bone was measured by marking two points on the plain paper. One point was marked at the uppermost margin of

the head and the other at the lowermost margin of the condyles. The distance between the two points representing the total length of the femur was recorded using a well-calibrated measuring tape. (Figure-1)

Figure-1. Methodology for the measurement of total length of femur

For the Shaft length of the femora, two points were marked on a clear chart paper. One from the lowermost margin of the lesser trochanter that presented the junction of the upper end with the shaft and the other from the uppermost margin of an epicondyle of the femur at the junction of shaft and lower end. The distance between the two points represented the femur's shaft length, which was recorded using a measuring tape of known calibration. (Figure-2)

The neck shaft angle was determined by drawing a straight midline axis of the shaft of the femur, and other from the midline of the neck of the femur by using straight, thin metal wires and a transparent scale ruler. The angle between the two axes representing the neck-shaft angle was measured using a goniometer. (Figure-3)

For measuring the angle of torsion, the bone was placed on a smooth horizontal surface, such that the condyles were resting over it completely. Thus, the surface was considered the axis of femoral condyles, and by using a transparent scale ruler, the axis of the head and neck was determined. The angle between the two axes was measured using a goniometer, showing the angle of torsion. (Figure-4)

Figure-2. Methodology for the measurement of shaft length of femur

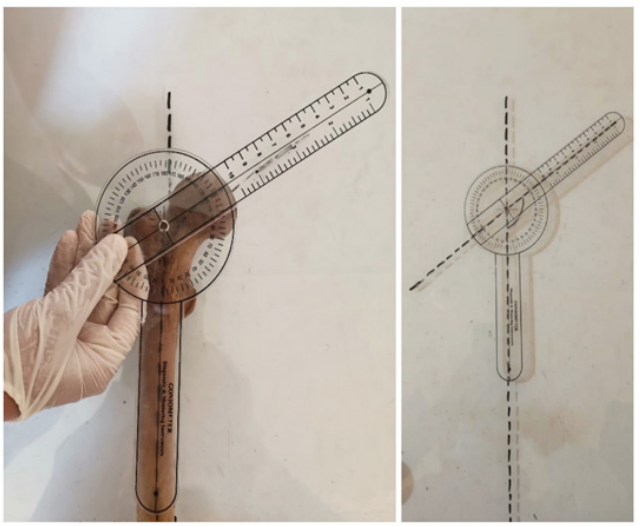

Figure-3. Methodology for the measurement of Neck-Shaft angle

Figure-3. Methodology for the measurement of Neck-Shaft angle

Data was entered into Microsoft Excel. SPSS Version 26 was used for data analysis. Independent Samples Student t test was used to compare means of all the quantitative variables.

RESULTS

Out of the 100 dry adult femora present in the bone bank of Rawalpindi Medical University, 20 were not anatomically fit for study due to broken parts. So, 80 bones were selected for study, 35 on the right side and 45 on the left side.

The total femur length was 43.75±3.01 cm and the femur shaft length were 30.21±2.54 cm. There was no significant difference between the two sides. (Table-I)

The mean neck shaft angle was 128.79±5.05 degrees with no difference between the sides. The mean angle of anteversion was 16.43±5.14 degrees with a significantly greater angle on the right compared to the left side (p=0.028). (Table-II)

	Side	N	Mean	P-Value
Total Femur Length (cm)	Right	35	43.17±3.13	0.128
	Left	45	44.20±2.87	
	Total	80	43.75±3.01	
Femur Shaft Length(cm)	Right	35	29.92±2.09	0.369
	Left	45	30.44±2.85	
	Total	80	30.21±2.54	

Table-I. Means and standard deviations of total femur length and femur shaft length

	Side	N	Mean	P-Value
Neck Shaft Angle (Degree)	Right	35	128.80±5.08	0.948
	Left	45	128.78±5.05	
	Total	80	128.79±5.03	
Angle of Femoral Neck Anteversion (Degrees)	Right	35	17.86±3.37	0.028*
	Left	45	15.32±5.98	
	Total	80	16.43±5.14	

Table-II. Means and standard deviations of angle of femoral neck anteversion and neck shaft angle

DISCUSSION

Anthropometric parameters of femur play an important role to understand the mechanization of movement and to design various means to treat clinical pathologies effectively. In our study, the mean of total length of the right and left of femur was 43.75±3.01cm which has also been reported by other Asian studies. Bhosale and Zambare reported that the mean length of right and left femora was 45.23cm and 42.04cm respectively.[8] Length variations do exist with other populations especially the west which may be due to variations in bone morphology, including hormonal genetic, diet and physical activity of people. We found no significant difference between the right and left length which has also been reported by other studies. However, in west, higher values were obtained showing variations regionally.[9] This bilateral symmetry shows synchronization of the right and left side of the body indicating systemic control.[10]

Angle of inclination, formed between the femoral shaft and inclined neck, normally, ranges between 125-135 degrees, with a mean value of 127° as per studies. Some conditions may lead to a higher value such as in Scoliosis patients have bilateral significantly greater values.[11] Studies depicted that in normal subjects, the femoral neck-shaft angle difference between the hips was not statistically significant.[12]

In accordance with the researches conducted across the globe, NSA showed no significant variation. For the populations of Europe, America and Asia the mean value of NSA between 126°-130°.[13] These variation can be related to climate, clothing and lifestyle. Based on Bergmann's rule NSA varies proportionally, with higher values related to warmer regions e.g., in Pacific (130°)

and lower values related to colder regions such as in Europe (126°) and America (125°). Moreover, NSA also tends to increase with changes in lifestyle pattern from rural to urban living.[14] NSA is not significantly affected by age.[15] Many published studies reported no specific difference except a little in NSA among male and female cadaveric femora having the values of 133.39±6.17° and 133.08±4.32° respectively. No significant laterality difference was reported in NSA except a greater value was obtained at the left side. A small lateral difference is seen forming basis of bilateral asymmetry in angle in some populations due to right leg dominance.[16] This is in accordance to our results where there is an insignificant difference in mean values bilaterally.

Clinically, FNA is extremely important in helping with diagnosis of various disorders. The children having the issue of toeing in and toeing out have shown relationships with the increased or decreased FNA thus helping in early diagnosis and management.[17] Moreover, FNA is much increased in people having osteoarthritis[18] and the patients of hip degenerative diseases also have association with FNA.[19] Increased FNA is also associated with the Anterior Cruciate Ligament(ACL) rupture.[20] Determination of FNA preoperatively in the patients of developmental dysplasia of the hip (DDH) helps the surgeon in the correct surgical approach of an individual. FNA measurement is also valuable in the postoperative examination of patients with total hip arthroplasty (THA), which would reduce the risk of dislocation afterwards.[21]

In our research we found that significant variation that exists bilaterally, we concluded that the mean value of right and left bones had an angle of anteversion of 17.8° and 15.2° respectively. African femurs have greater angles 21.90 ± 5.90 and 18.90 ± 4.70 among the right and left side of bones respectively.[22] Studies have also reported regional variation in the angle of anteversion that exist among Americans, Europeans and Asians also[23], which shows that geographical, hereditary and behavioural factors do influence the FNA. This may be due to variable socioeconomic conditions of different areas.[24]

The limitation of our study is that gender and age of the femora could not be taken into consideration as they were obtained from the bone bank.

CONCLUSION

In Pakistani Femur there is no significant difference in the total, shaft lengths and neck shaft angles on the right and left sides. However, the Angle of Femoral Neck Anteversion is significantly greater on the right as compared to the left. Also, this angle is less than reported in African and more than reported in American and European population.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

No.	Author(s) Full Name	Contribution to the paper	Author(s) Signature
1	Arsalan Manzoor	Substantial contribution to be conception, Data analysis, Revising it critically for the important intellectual content, Final approval of the version to be published.	
2	Sarwar Zia	Critical review of the article.	
3	Aiema Hamid	Substantial contribution to the design of work, Interpretation of data, Drafting of work.	
4	Gulzeryam Muneer	Substantial contribution to the design of work, Interpretation of data, Drafting of work.	
5	Hamna Sarwar	Critical review of the article.	