 DOI: 10.5958/2394-2126.2016.00097.9

Examination evaluation and statistical analysis of human femoral anthropometry in Hyderabad and Secunderabad regions, India

Peter Ericson Lingamdenne[1,*], Pavani Marapaka[2]

[1,2]Assitant Professor, Dept. Anatomy, Kamineni Academy of Medical Sciences & Research Centre, Telangana

***Corresponding Author:**
Peter Ericson Lingamdenne
Assitant Professor, Dept. Anatomy, Kamineni Academy of Medical Sciences & Research Centre, Telangana
Email: peterericson7@gmail.com

Abstract

Background: Femur, the longest and strongest bone in the human body, presents many anatomical variations, influenced by race, region, gender, occupation, and diet. Complete knowledge of its anatomy is required to understand different pathologies affecting the femur and hip joint.

Objective: The purpose of this study was to evaluate the osteometric measurements of the dry human femur of Hyderabad and Secunderabad population. Clinical relevance, correlation between these parameters, comparison with other population groups, along with review of literature is presented in this paper.

Materials and Methods: In this study anthropometric evaluation of 50 dry human femurs was done. Twelve parametric variables related to the femur were obtained from the head, neck, shaft, and distal end of the femur. The observed measurements were subjected to statistical analysis and the results are presented in this paper.

Results and Conclusion: The precise anthropometric measurements of the adult femur in the Hyderabad and Secunderabad regions are reported in this paper. This data could be helpful to understand the normal anatomy of femur, play an important role in the management of different pathologies affecting the femur and hip joint, assist in forensic cases, and contribute to demographic studies.

Keywords: Femur, Head, Neck, Neck-shaft angle.

Introduction

Femur is the longest long bone in the human body. It is also the strongest bone and transmits the weight of the upper body to the lower limb via the hip joint. It has an intracapsular head, the shape of which is more than half a sphere, and it is a component of the hip joint. The neck of femur, around 5cm in length, makes an angle of inclination of 125^0 with the shaft. At the neck-shaft junction, the quadrangular greater trochanter and conical lesser trochanter are present. The femoral shafts are partly cylindrical, partly triangular, and in anatomical position the femoral shafts are obliquely placed. The distal end of femur has two massive condyles, which are partly articular[1].

The length of the femur can be evaluated by two variables the maximum length and trochanter length of the femur. These vary in different population groups, and are influenced by gender, diet, and occupational variations. These measurements are important while designing intramedullary femoral implants, and surgical management of femoral shaft fractures. They can also be used to determine the stature of a person and assist in forensic cases[2]. These parameters along with the shaft measurements are vital in designing artificial limb prosthesis[3].

Neck-shaft angle also known as the collo-diaphyseal angle is the angle of inclination which the neck of femur makes with the shaft. This neck shaft angle allows the limb to swing clear of the pelvis during movements at the hip joint. It is highest in infants, progressively decreases with age[4], and the angle is more in males than females[5]. The neck shaft angle shows climatic variations; higher in warmer regions and lower in colder climates[6]. Lifestyles, occupation, economic status also influence the neck shaft angle; increase of the angle from rural to urban population[6]. This angle varies in different pathological disorders; when this angle is more than 135^0, condition is known as coxa valga, when less than 120^0, coxa vara. The neck-shaft angle is an important parameter to predict the risk for a hip fracture, especially in osteoporosis, and to start preventive treatment if there is an increased risk[7]. Radiography of the neck shaft angle aids in the diagnosis and further management of femoral neck fractures[8]. The neck shaft angle is important to an orthopedic surgeon, in choosing the optimal implant while treating fractures of the proximal femur especially femoral neck fractures[9]. There is variation of this angle in different ethnic groups and the measurements observed in this study can be used to design implants for total hip replacement surgery suitable for people of this region.

The fractures of proximal femur have become increasingly common and the measurement of proximal width of the femur is important while selecting an appropriate implant to fix the fractures surgically [10]. This along with the distal width of the femur can be used to determine the stature of an individual, assist in forensic cases[2], and contribute to anthropological studies.

Various disorders affect the hip joint, the treatment for some of which is unilateral or bilateral hip arthroplasty. The prosthesis for the femoral component is designed based on the femoral head and neck diameters[11].

The anthropometry measurements of femur differ from region to region influenced by variations in race, age, gender, life style, climate, diet. These measurements have immense value in forensic medicine, archaeology, prosthetics, surgery, and biomedical engineering.

Materials and Methods

In this study, 50 intact human adult femurs were obtained from the teaching skeletal collections of medical colleges in Hyderabad and Secunderabad regions. The bones were of unknown gender.

Inclusion criteria: Adult, intact femurs with clear features.

Exclusion criteria: Broken, incomplete bones.

Of the fifty femurs 23 belonged to the right side and 27 to the left side.

Sliding Vernier calipers, osteometric board, measuring scale were used for taking linear measurements, and measuring tape for circumferential measurements. Angular measurements were taken using a goniometer.

In this study, a total of 12 parametric variables related to the femur were obtained from the head, neck, shaft, proximal and distal end of the femur.

The following osteometric measurements of the femur were taken:

1. Maximum length (ML; Fig. 1A): Distance from the head of the femur to the medial condyle.
2. Trochanter length (TL; Fig. 1B): Distance from the tip of the greater trochanter of the femur to the lateral condyle.
3. Neck-shaft angle / Collo-diaphyseal angle (NSA; Fig. 1C): The angle between the longitudinal axis of the neck and the longitudinal axis of the shaft of the femur.
4. Proximal breadth (PB; Fig. 2A): Maximum width between the head of the femur and the greater trochanter.
5. Distal breadth (DB; Fig. 2B): Maximum width between the epicondyles of the femur.
6. Head vertical diameter (HVD; Fig. 2C): Maximum vertical diameter of the femoral head.
7. Head transverse diameter (HTD; Fig. 2D): Maximum antero-posterior diameter of the head of the femur.
8. Neck vertical diameter (NVD; Fig. 2E): Minimum diameter of the neck of the femur in the vertical plane.
9. Neck transverse diameter (NTD; Fig. 2F): Minimum diameter of the neck of the femur in the horizontal plane.
10. Mid-shaft circumference (MSC; Fig. 3A): Circumferential measurement of the mid-shaft of femur.
11. Mid-shaft antero-posterior diameter (MSAPD; Fig. 3B): Minimum antero-posterior diameter at the middle of the shaft of the femur.
12. Mid-shaft transverse diameter (MSTD; Fig. 3A): Minimum transverse diameter at the middle of the shaft of the femur.

The measurements were taken thrice by the same author in order to avoid errors.

The data was statistically analyzed using SPSS version 17.0, and the Pearson correlation coefficient between the femoral osteometric measurements was obtained.

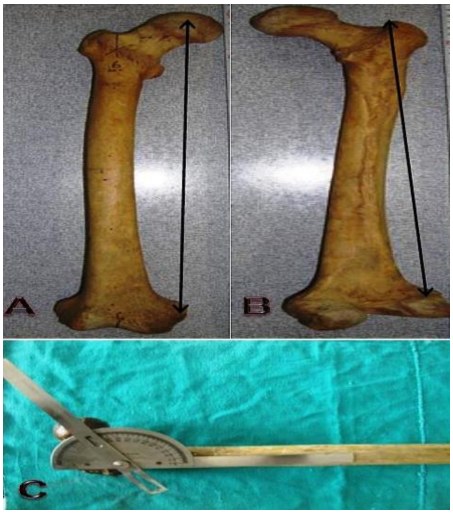

Fig. 1: Osteometric measurements of Femur
A- Maximum length (ML), B- Trochanter length (TL), C- Neck-shaft angle (NSA)

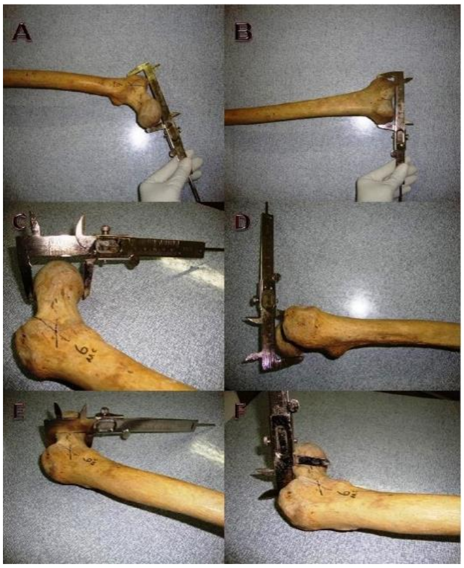

Fig. 2: Osteometric measurements of femur (continued)

A- Proximal breadth(PB), B- Distal breadth(DB), C- Head vertical diameter(HVD), D- Head transverse diameter(HTD), E- Neck vertical diameter(NVD), F- Neck transverse diameter(NTD)

Fig. 3: Osteometric measurements of femur (continued)
A- Mid-shaft circumference (MSC). B- Mid-shaft antero-posterior diameter (MSAPD), C- Mid-shaft transverse diameter (MSTD)

Results and Discussion

Several disorders affect the femur and hip joint, and the anthropometric measurements are a valuable tool for the clinician to diagnose, and manage the various disorders. These values show ethnic and racial variations and are of immense value to anatomists, anthropologists, and forensic experts.

In our current study the maximum length and trochanter length showed strong correlation with the proximal breadth, and the mid shaft parameters. Vaghefi et al[3] observed the values of 44.99cm and 40.81cm, in Iranian males and females respectively, while Zuylan et al[12] reported the maximum length of femur as 42.8cm on the left side and 41.6cm on the right side in Turkish people. In the present study we found the maximum length of the femur to be 43.02cm similar to the values reported in other south Indian studies; 44.62cm as reported by Khan et al[4], and 43.74cm as recorded by Pillai et al[13].

We recorded the trochanter length as 40.85cm, while similar values of 40.5cm and 40.2cm on the left and right femur respectively have been reported in Turks[12].

The neck shaft angle has immense functional and surgical significance and varies considerably among different population groups. It varies with age, and is influenced by several factors including climate, occupation, race and ethnicity. The highest Neck-shaft angle values were reported by Khan et al[4] among the south Indians 137.10^0. Similar studies among the south Indians revealed lower values of 128.09^0 and 125.3^0as recorded by Vemavarapu et al[5] and Pillai et al[13] respectively. Kaur et al[8] observed a value of 121^0 among North West Indians close to our value of 119.44^0. Values of 132.26^0 were recorded among the Nepalese by Mishra et al[14], 132.1^0 in Brazilians by Desousa et al[15], 130.77^0 in Nigerians by Adekoya[16], and 127.7^0 among Norwegians as reported by Rerikeras et al[17]. Zuylan et al[12] reported the neck shaft angle as 128.7^0 on the left side and 127.6^0 on the right side in Turkish people. Gender based differences were seen in the Malay population 132.33^0 in males and 129.87^0 in females as reported by Baharuddin et al[9] and also in the south Indian Population as observed by Vemavarapu et al[5] who recorded a value of 128.04^0 in males and 127.20^0 in females. In both these studies the neck shaft angle was higher in males as compared to females. Neck shaft angle varies with width of pelvis and stature, showing a lower value in women, and in persons with short limbs. Gilligan et al[6] compiled a global database of the neck shaft angle and recorded the measurements of 8000 femurs belonging to 100 human groups. He reported that the average value of the neck shaft angle was 127^0. He also observed that the value is higher in warmer regions like the pacific, 130^0, and lower in colder regions like Europe and America where he recorded values of 126^0 and 125^0 respectively. An increase of one standard deviation in neck-shaft angle and an increase of one standard deviation in mean femoral neck width are associated with increased risk of hip fracture as reported by Alonso et al[7]. In our study neck shaft angle showed a positive correlation with the proximal breadth and negative correlation with the distal breadth.

We recorded the proximal breadth value as 8.64cm, and distal breadth values as 7.38cm. Zuylan et al[12] in his studies among the Turks reported proximal breadth values of 9.01cm on the left side and, 9.02cm on the right side which were close to our measurements. He observed distal breadth values of 7.73cm and 7.68cm in the left and right femur respectively. We observed in our study that there is a strong correlation between the proximal breadth and the length of the femur as compared to the distal breadth.

The measurements of the head are vital in hip joint pathologies, and form a valuable guide to design a suitable implant in total hip replacement surgeries. An optimal implant will benefit the patient; prevent post-operative complications and last longer[11].

In our present study we observed the mean head vertical diameter value of 4.23cm, similar to the value of 4.22cm as reported by Pillai et al[13]. Higher values were observed in Turks by Zuylan et al[12] who reported mean values of head vertical diameter as 4.34cm and 4.52cm, on the left and right side respectively. He observed mean head transverse diameter values of 4.43cm and 4.47cm on the left and right side respectively. Mishra et al[14] reported head diameter values of 4.29cm among the Nepalese. Vaghefi et al[3] in their study among the Iranians, reported mean head vertical diameter values of 4.6cm in males, 4cm in females and mean head transverse diameter values of 4.57cm in males, and 4.02cm in females respectively. Baharuddin et al[9] reported head transverse diameter values of 4.36cm and 3.88 in Malaysian males and females respectively.

Neck of femur is clinically important, commonest site to fracture in osteoporosis, associated with congenital anomalies and is frequently operated upon by the orthopedic surgeons. The osteometric parameters of the neck along with bone mineral density are important factors to determine the risk of fracture especially in osteoporosis[7].

In our current study we recorded neck vertical diameter values of 2.96cm. Higher values were reported among the Turks 3.06cm and 3.07cm on the left and right side respectively[12]. We observed neck transverse diameter value of 2.48cm, close to the value recorded among the Turks 2.55cm, and 2.63cm on the left and right side respectively[12]. The diameter of the femoral neck was reported as 3.32cm in Nepalese[14], 3.11cm in Brazilians[15], 2.89cm and 2.49cm in Iranian males and females' respectively[3]. Baharuddin et al[9] observed values of 2.88cm and 2.59, in males and females respectively among the Malaysian population. In most of these studies the head and neck parameters showed higher values in males than in females. In our study the transverse and vertical measurements of the head and neck also showed strong correlation with the maximum as well as the trochanter length of the femur.

Zuylan et al[12] in his studies reported mid-shaft circumference values of 8.72cm, and 8.62cm, mid-shaft antero-posterior diameter values of 2.68cm, and 2.71cm, and mid-shaft transverse diameter values of 2.68cm, and 2.64cm on the right and left side respectively. We observed much lower values of mid-shaft circumference 7.71cm, mid-shaft antero-posterior diameter 2.58cm, and mid-shaft transverse diameter 2.53cm. Pillai et al[13] reported similar values of mid shaft antero-posterior diameter 2.63cm, while higher values were reported among the Iranians by Vaghefi et al[3] 2.85cm and 2.48cm in males and females respectively. In our study the mid shaft parameters showed a positive correlation with the length of femur as well as the proximal breadth of femur.

A summary of the measurements of the different parameters of the femur, the mean, standard deviation, minimum and maximum values have been tabulated in Table 1.

The Pearson correlation coefficient values between the femoral osteometric measurements are tabulated in Table 2, 3.

Table 1: Measurements of femur parameters

Measurements of Femur	Mean	Standard Deviation	Minimum	Maximum
Maximum length(cm)	43.02	2.30	39.0	48.0
Trochanter length(cm)	40.85	2.20	37.0	46.0
Neck – shaft angle (degree)	119.44^0	4.13	112^0	130^0
Proximal breadth(cm)	8.64	.50	7.55	9.75
Distal breadth(cm)	7.38	1.00	1.12	8.74
Head vertical diameter(cm)	4.23	.54	1.14	5.02
Head transverse diameter(cm)	4.23	.33	3.50	5.00
Neck vertical diameter(cm)	2.96	.26	2.42	3.52
Neck transverse diameter(cm)	2.48	.23	1.95	3.05
Mid-shaft circumference(cm)	7.71	.61	7.00	10.00
Mid-shaft antero-posterior diameter(cm)	2.58	.23	2.14	2.97
Mid-shaft transverse diameter(cm)	2.53	.22	2.03	3.30

Table 2: Pearson correlation coefficients between the femoral osteometric parameters

Measurements of Femur	ML	TL	NSA	PB	DB	HVD	HTD
ML	1	.982**	.281*	.601**	.257	.413**	.632**
TL	.982**	1	.218	.586**	.251	.388**	.603**
NSA	.281*	.218	1	.355*	-.076	.126	.397**
PB	.601**	.586**	.355*	1	.416**	.423**	.634**
DB	.257	.251	-.076	.416**	1	.904**	.325*
HVD	.413**	.388**	.126	.423**	.904**	1	.593**
HTD	.632**	.603**	.397**	.634**	.325*	.593**	1
NVD	.643**	.647**	.253	.555**	.197	.376**	.793**
NTD	.496**	.468**	.271	.349*	.251	.417**	.676**
MSC	.610**	.637**	.357*	.499**	.195	.371**	.648**
MSAPD	.441**	.453**	.151	.702**	.379**	.317*	.398**
MSTD	.586**	.571**	.520**	.516**	.117	.326*	.580**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 3: Pearson correlation coefficients between the femoral osteometric parameters (continued)

Measurements of Femur	NVD	NTD	MSC	MSAPD	MSTD
ML	.643**	.496**	.610**	.441**	.586**
TL	.647**	.468**	.637**	.453**	.571**
NSA	.253	.271	.357*	.151	.520**
PB	.555**	.349*	.499**	.702**	.516**
DB	.197	.251	.195	.379**	.117
HVD	.376**	.417**	.371**	.317*	.326*
HTD	.793**	.676**	.648**	.398**	.580**
NVD	1	.638**	.585**	.381**	.508**
NTD	.638**	1	.490**	.282*	.266
MSC	.585**	.490**	1	.423**	.471**
MSAPD	.381**	.282*	.423**	1	.244
MSTD	.508**	.266	.471**	.244	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Conclusion

The exact measurements of various parameters of the dry femur in the Hyderabad and Secunderabad region, India have been statistically analyzed, and presented in this paper. Comparison with studies in people from different regions, revealed variations in the osteometric values of the femur, the basis of which could be attributed to racial and ethnic differences. Knowledge of the normal osteometric values, correlation between these parameters, and regional variations of femur is important for medical practitioners to understand, treat different disorders of the femur and hip joint. This data is essential to design implants for the hip joint in this region. This data can also be used for demographic studies, and assist in forensic cases.

Financial or Other Competing Interests: None.

References

1. Standring. S. Gray's Anatomy: The Anatomical Basis of Clinical Practice 39th Ed. New York: Churchill Livingstone 2008;819-21.
2. Ajay M. Parmar, Kanan P. Shah, Jatin Goda, Brijesh Aghera, G. C. Agarwal. Reconstruction of total length of femur from its proximal and distal fragments. Int J Anat Res. 2015;3(4):1665-1668.
3. Seyed Hassan Eftekhar Vaghefi, Leila Elyasi Saeed Reza Amirian, Parviz Raigan, Hakimeh Akbari, Mina Sheikhshoaiee, Arash Borbor. Evaluating Anthropometric Dimensions of the Femur Using Direct and Indirect Methods. Anatomical sciences. 2015;12(2):89-92.
4. Shakil Mohamad Khan, Shaik Hussain Saheb. Study on neck shaft angle and femoral length of south Indian femurs. Int J Anat Res. 2014;2(4):633-635.
5. Mahesh Vemavarapu, Jyothinath Kothapalli, Vijayendranath, Kulkarni. Estimation of collo-diaphyseal angle of femur by Martin's dioptrograph: a comparative study. Int J Anat Res 2016;4(1):1772-1776.
6. Gilligan I, Chandraphak S, Mahakkanukrauh P. Femoral neck-shaft angle in humans: variation relating to climate, clothing, lifestyle, sex, age and side. J Anat. 2013;223(2):133-51.

7. Alonso CG, Curiel MD, Carranza FH, Cano RP, Peréz AD. Femoral bone mineral density, neck-shaft angle and mean femoral neck width as predictors of hip fracture in men and women. Multicenter project for research in osteoporosis. Osteoporos Int. 2000;11(8):714-20.
8. Kaur P, Mathew S, George U. A study of neck shaft angle in the north-west Indian population on radiographs. International Journal of Basic and Applied Medical Sciences. 2013;3(3):9-15.
9. Baharuddin, M. Y, Kadir M. R. A, Zulkifly, A. H, Saat, A, Aziz, A. A, Lee M. M. Morphology study of the proximal femur in Malay population. Int. J. Morphol. 2011;9(4):1321-1325.
10. Devendra Pathrot, Rehan Ul Haq, Aditya N Aggarwal, Mahindra Nagar, Shuchi Bhatt. Assessment of the geometry of proximal femur for short cephalomedullary nail placement: An observational study in dry femora and living subjects. Indian J Orthop. 2016;50(3):269–276.
11. D. Ravichandran, N. Muthukumaravel, R. Jai Kumar, Hirak Das, Melani Rajendran. Proximal femoral geometry in Indians and its clinical applications. J.Anat.soc.India. 2011;60(1):6-12.
12. Taner Züylan, Khalil Awadh Murshid. An analysis of Anatolian human femur anthropometry. Turkey journal of medical sciences. 2002;32:231-235.
13. T. Jayachandra Pillai, C.K. Lakshmi Devi, T. Sobha Devi. Osteometric Studies on human femurs. IOSR Journal of Dental and Medical Sciences. 2014;13(2):34-39.
14. AK Mishra, P Chalise, RP Singh, RK Shah. The proximal femur - a second look at rational of implant design. Nepal Med Coll J 2009;11(4):278-280.
15. De Sousa, E, Fernandes R. M. P, Mathias M. B, Rodrigues M. R, Ambram, A. J, Babinski M. A. Morphometric study of the proximal femur extremity in Brazilians. Int. J. Morphol. 2010;28(3):835-840.
16. Adekoya-Cole TO, Akinmokun OI, Soyebi KO, Oguche OE. Femoral neck shaft angles: A radiological anthropometry study. Niger Postgrad Med J. 2016;23(1):17-20.
17. Olav Reikeras, Arne Hoisemz, Astor Reigstad, Erik Fonstelien. Femoral neck angles; A Specimen study with special regard to bilateral differences. Acta orthop. Scand.1982;(53):775-779.