Research Article

Estimation of Length of Femur from their Proximal Segments in Population of Eastern Odisha

Santosh Kumar Sahu [1]*, Sujita Pradhan [2], Lopamudra Nayak [3].

1. Professor, Dept. of Anatomy, Bhima Bhoi Medical College, Bolangir, Odisha, India.

2. Assistant Professor, Dept. of Anatomy, IMS & SUM Hospital, Bhubaneswar, Odisha, India.

3. Assistant Professor, Dept. of Anatomy, IMS & SUM Hospital, Bhubaneswar, Odisha, India.

***Corresponding author's E-mail:** dr.santoshmailbox@rediff.com

Received: 19-03-2024; **Revised:** 22-05-2024; **Accepted:** 03-06-2024; **Published on:** 15-06-2024.

ABSTRACT

Estimation of stature plays a vital role in the field of forensic anthropology. An intact femur, bearing the highest degree of correlation with the stature, is widely used for deriving regression equation for estimating stature. As dimensions of femur bones varies from region to region and in different ethnic groups, population specific formula for estimation of femoral length is required. The present study was carried out to find out a correlation between length of femur and dimensions of its proximal segment in population of Eastern Odisha and to derive regression equations for the same. A cross-sectional study was conducted at the Anatomy department of SCB Medical College, Cuttack, India taking into account dried specimens of 20 adult human femora. Osteometric board, flexible measuring tape and Vernire caliper were used for measurement of various parameters like: Length of Femur (FL), Anterior Neck Length (ANL), Width of Shaft (WS), Intercondylar Width (ICW), Vertical Diameter of Neck (VDN), Transverse Diameter of Neck (TDN) of Femur. All the measurements were tabulated and analyzed statistically using Pearson's correlation coefficient and linear regression analysis. The p-value of <0.05 was considered as significant. The mean length was found to be 415 mm and was found significantly lower than femora belonging to other populations. The present study showed statistically significant linear correlation between length of femur with Width of Shaft, Intertrochanteric Width, Transverse and Vertical Diameters of Neck.

Keywords: Stature, Femur, Pearson's correlation coefficient, Linear regression.

INTRODUCTION

Estimation of stature plays a pivot role in the field of forensic anthropology. It is a vital segment in the line of identification of an individual, living or dead[1]. Different body parts can be used for the estimation of stature of an individual but the weight bearing bones of lower limb have the highest degree of correlation with stature[2-5]. Femur is the longest and stoutest bone in the human body with its shaft, proximal and distal ends[6]. An intact femur which has the utmost degree of correlation with the stature of the individual is widely taken for deriving regression equation for estimating stature[3].

In cases where the intactness of the femur is lost, estimation of stature from femur becomes difficult where regression equation for length of femur from its fragments helps in estimating its approximate length and thereby stature of the concerned person[7]. Dimensions of femur varies from region to region and in different ethnic groups and hence population specific formula for estimation of femoral length is required[2].

The present study was carried out to find correlation between length of femur with dimensions of its proximal segment in population of Eastern Odisha and to derive regression equations for the same. This study will be much valuable for forensic investigators and archaeologists, especially when they could find only fragmentary proximal parts of femur bones of human remains .

MATERIALS AND METHODS

The present study was a across-sectional, observational study conducted at the department of Anatomy of SCB Medical College, Cuttack, India taking into account dried specimens of 20 adult fully ossified human femora. Bone specimens with pathological changes such as cortical bone deterioration, arthorses, extreme osteophytic activity, diffuse osteoarthritis, fracture and visible abnormalities were excluded from the study. Osteometric board, flexible measuring tape and Vernire caliper were used for measurement of various parameters. All measurements were repeated thrice by same observer and the mean values were recorded to minimize error during measurement. Values were measured in millimeters [Table-1].

1. The Length of Femur (FL) was measured from the highest point on its head and the lowest point on its medial condyle with the help of osteometric board
2. Anterior Neck Length (ANL) was measured anteriorly from the base of the head to the mid-point of the intertrochanteric line
3. Width of Shaft (WS)
4. Intercondylar Width (ICW) was measured by Venire Caliper placing it parallel to the joint line.
5. Vertical Diameter of Neck (VDN) was measured as the straight distance between highest and deepest point of neck of femur
6. Transverse Diameter of Neck (TDN)

Statistical Analysis

All the measurements were recorded in a tabular form and analyzed statistically [Table-1]. Minimum, maximum, mean, standard deviation and p-values were found out. Pearson's correlation coefficient was taken into account to find a correlation between FL and dimensions of its proximal segment [Table-2]. The p-value of < 0.05 was valued as significant and < 0.01 highly significant.

Table 1: Statistical analysis between length of femur (FL) and dimensions of their proximal segments

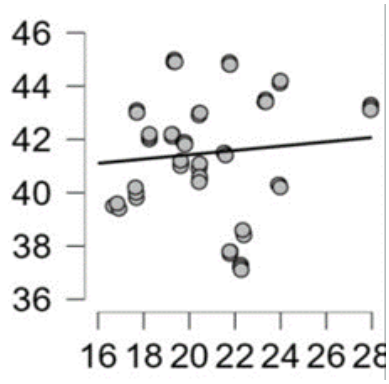
	Mean Total Femur Length (mm)	Mean Anterior Neck Length (mm)	Mean Width of Shaft (mm)	Mean Intertrochanteric Width (mm)	Mean Vertical Diameter of Neck (mm)	Mean Transverse Diameter of Neck (mm)
Valid	210	21	21	21	21	21
Missing	400	40	40	40	40	40
Mean	415	20.577	24.022	20.56	28.198	24.756
Std.Deviation	21.52	2.587	1.573	1.985	1.591	2.165
Shapiro-Wilk	09.74	0.967	0.953	0.933	0.938	0.938
P-value of Shapiro-Wilk	08.22	0.664	0.385	0.161	0.199	0.196
Minimum	372	16.84	20.435	16.68	24.89	21.04
Maximum	449.33	25.965	26.895	23.37	30.265	28.33

The length of femur ranged from 372 mm to 449.3 mm with mean length 415 mm and standard deviation 21.52 mm among the 20 femora.

Table 2: Pearson correlation coefficient between length of femur (FL) and dimensions of their proximal segments.

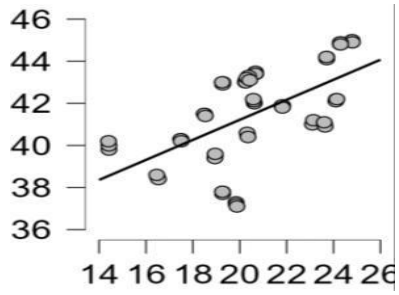
Variable		Total Femur Length (cm)
1. Total Femur Length (cm)	Pearson's r	—
	p-value	—
2. Anterior Neck Length (mm)	Pearson's r	0.097
	p-value	0.463
3. Width of Shaft (mm)	Pearson's r	0.605
	p-value	< .001
4. Intertrochanteric Width (mm)	Pearson's r	0.598
	p-value	< .001
5. Vertical Diameter of Neck (mm)	Pearson's r	0.642
	p-value	< .001
6. Transverse Diameter of Neck (mm)	Pearson's r	0.588
	p-value	< .001

The scatter diagrams were drawn to show the relationship between length of femur with various parameters of upper end of femur like proximal width, vertical and transverse diameter of head of femur, circumference of head, vertical and transverse diameter of neck of femur [Fig. 1-4].



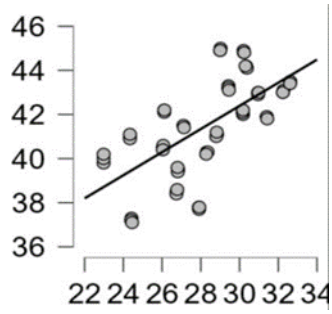
R^2=0.355

Figure 1: Correlation between Length of Femur & Width of Shaft



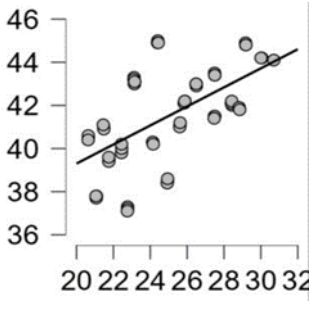
R^2= 0.358

Figure 2: Correlation between Length of Femur & Intertrochanteric Width



R^2= 0.413

Figure 3: Correlation between Length of Femur & Vertical Diameter of Neck



R^2=0.346

Figure 4: Correlation between Length of Femur & Transverse Diameter of Neck

The R^2 is the coefficient of determination, the value of coefficient of determination talks about strength of relationship between two variables. The coefficient of determination was maximum (0.413) between femur length and vertical diameter of neck [Fig.-3].

Scatter diagrams revealed that the relationship between total length of femur with proximal segment measurements was positive and linear and didn't display any bivariate outliers.

Table 3: Analysis of standard residual data:

Parameter	Std. Residual - Minimum	Std. Residual - Maximum	Durbin Watson Test (d)	R^2	p-Value
FL vs WS	-1.89	1.56	0.767	0.335	<0.001
FL vs ITW	-2.33	1.23	0.878	0.358	<0.001
FL vs VDN	-2.16	1.87	0.854	0.413	<0.001
FL vs TDN	-1.95	2.13	0.847	0.346	<0.001

Analysis of standard residual data revealed no outliers [Table-3]

Table 4: Regression Equations for estimation of length of femur

SL. NO.	Regression Equations
1	FL =27.341+0.59(WS)
2	FL=31.69+0.47(ITW)
3	FL =26.66+0.52(VDN)
4	FL =30.46+0.44(TDN)

Linear regression equations were worked out to predict the length of femur from its proximal segment measurements [Table-4]. Anterior neck length did not express any statistically significant correlation with femoral length so regression equation for the same couldn't be found out.

DISCUSSION

Stature is a salient anthropometric specification to prove an individual's identity in medico-legal cases relating to skeletal remains analysis. Stature is evaluated by analyzing combined dimensions of bones responsible for height or by regression equations made from intact measured long bone length dimensions. In some situations, like a mass mishap, these methods cannot be utilized as intact long bones are unobtainable. The convenient regression equations for estimation of statute are not broadly admissible to the diversity of population as these equations are population specific. The anthropometric dimensions vary from population to population resulting from genetic and environmental impact on growth and development of an individual.

In the present study, length of femur and various parameters of its proximal segment of 20 femora were measured and analyzed statistically using Pearson's correlation coefficient and linear regression analysis. The mean length of femur in our study was found to be 415 mm which is significantly lower than femora belonging to other populations. The mean length of femur is maximum among South Africans (454.56±24.67 mm)[10] followed by French (443.6±21.8 mm) [8] and Japanese (401.27±17.40 mm) [9] population. Mean length of Femur among Indian studies are: Leelavathy N et al. Bangalore (433.52±19.80mm) [11], Gargi Soni et al., Rohtak (425.09±26.18mm) [13], C Magendran, Chennai (390.5±10.4mm) [1]. In the present study we reported length of femur 412.56±30.34 which shows regional and racial variations in length of femur.

Table 5: Comparison of present study with studies done by other workers in different ethnic groups

SL. NO.	Name of worker	Sample size	Mean	SD	P-value
1	C Magendran, Chennai[1]	60	390.5	10.4	**<0.01**
2	Rubin PJ et al, France [8]	32	443.6	21.8	**<0.01**
3	Ozerl, Japanese [9]	45	401.27	17.4	**<0.01**
4	Steyn M, South Africa[10]	106	454.56	24.67	**<0.01**
5	Leelavathy, Bangalore [11]	40	433.52	19.8	**<0.01**
6	Jubilant K et al, Ghana[12]	50	449.7	23.4	**<0.01**
7	Gargi Soni et al, Rohtak [13]	80	425.01	26.18	**<0.01**
8	Present Study, Eastern Odisha, India	20	415	21.53	**<0.01**

LIMITATIONS

The study sample size was very small and mostly consisted of specimens from few donated dead bodies and dead bodies of destitute making it a convenience sample which can't be applied to the general population. Sexual dimorphism in the morphometry of femur has not been taken into account while selecting femur for the study. Demographic profile such as age, occupation, sex and nutritional status etc. were unknown. The precision of measurements could have been increased by use of digital calipers.

CONCLUSION

The present study showed statistically significant linear correlation between length of femur with Width of Shaft, Intertrochanteric Width, Transverse and Vertical Diameters of Neck of femur. The study data could be highly valuable for forensic investigators and archaeologists for calculation of length of femur and thus estimation of stature of an individual, especially when proximal fragmentary parts of femur are obtained from disputed dead body remains.

Source of Support: The author(s) received no financial support for the research, authorship, and/or publication of this article

Conflict of Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

1. Chandran M, Vijayakumari N. Reconstruction of Femur Length From Its Fragments in South Indian Females. International Journal of Medical Toxicology and Forensic Medicine. 2011;1(2):45-53.
2. Singh S, Nair SK, Anjankar V, Bankwar V, Satpathy DK, Malik Y. Regression equation for estimation of femur length in central Indians from inter-trochanteric crest. J Indian Acad Forensic Med. 2013;35(3):223-26.
3. Asha KR, Vinaykumar K, Bindurani MK, Kavyashree AN, Subhash L. Reconstruction of femoral length from its proximal fragments and diaphyseal segments in south indian population. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2014;5(5):920-25.
4. Parmar AM, Shah KP, Goda J, Aghera B, Agarwal GC. Reconstruction of total length of femur from its proximal and distal fragments. Int J Anat Res. 2015;3(4):1665-68.
5. Trotter M, Gleser G. A re-evaluation of estimation of stature based on measurements taken during life and the long bones after death. Am J Phys Anthropo. 1958;16:79-123.
6. Standring S, Borley NR, Collins P, Crossman AR, Gatzoulis MA, Healy JC, et al., editors. Gray's Anatomy. The Anatomical Basis of Clinical practice. 40 ed. London: Churchill livingstone Elsevier 2008.
7. Rother P, Jahn W, Hunger H, Kurp K. Determination of body height from fragment of the femur. Gegenbaurs Morphol Jahrb. 1980;126(6):873-83.
8. Rubin PJ,Leyvraz PF, Aubaniac JM, Argenson JN, Esteve P, Roguin BD.The morphology of the proximal femur: a three-dimensional radiographic analysis. J Bone Joint Surg Br. 1992;74(1):28–32.
9. OzerI, Katayama K. Sex determination using the femur in an ancient Japanese population. Coll Antropol. 2006;32(1):67-72.
10. SteynM, Iscan MY. Sex determination from the femur and tibia in South African whites. Forensic SciInt. 1997;90:111-19
11. Leelavathy N, Rajangam S, Janakiram S, ThomasI. Sexing of the femora. Journal of the Anatomical Society of India.2000;49(1):10-16
12. Jubilant KA, EricBO, Casmie lKO. Reconstruction of femoral length from fragmentary femora. Anat Cell Bio. 2016;49:206-09.
13. Soni G, Dhall U, Chhabra S. Determination of sex from femur: Discrimination analysis.J Anat Soc India. 2010;59(2):216-21.