Reconstruction of Length of Femur from Its Fragments- A Preliminary Study in Eastern Indian Population

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Abstract

Stature being a very important data for creating the identification profile of any individual, has immense anthropological and forensic importance. Often the unavailability of intact long bones poses for difficulty to estimate the stature. So reconstruction of the total femoral length from its different fragments by applying desired statistical methods can be used as a very important tool for it. The present cross-sectional study was designed aiming for a specific formula-based model in Eastern Indian population. Fully ossified, intact, dried 60 femora of Department of F.S.M., Burdwan Medical College were measured using Hepburn's Osteometric Board and sliding digital. All the measurements were performed by multiple examiners to exclude observer biasness and the mean value was recorded. Linear regression analysis was performed using maximum Femur length as the dependent variable and the different fragments as predictors to form a linear relationship with help of SPSS Statistical software. P value of <0.05 was considered significant. Among all the measured data, the Epicondylar Breadth, Midshaft antero-posterior Diameter and Transverse Head Diameter were found as statistically reliable predictors for determination of the maximum Femoral length. This finding is thus helpful in practical scenario when either the upper end or lower end of the femur is destroyed.

***Key Words**: Stature, Identification, Eastern-Indian, Correlation, Femoral Length, Femoral fragments.*

Introduction

Estimation of stature from bones, specially the long bones has immense anthropological and forensic importance. In practical forensic application, often intact bones are not available due to mutilation or post mortem predation by animals. Therefore, reconstruction of total length of femur from its bony fragments, by applying the desired statistical methods, is necessary for building a biological profile. It has been established that femur along with tibia provide reconcilable results. Different fragmentary lengths are widely used for deriving the regression equation for estimation of Femoral maximum length which in turn can be used as a very important tool for estimating the stature.

Pearson[1] and Trotter and Glesser[2] were two pioneers of this type of anthropometric studies. Later, their researches induced several important studies like researches on Turkish population by Pelin[3] and South Africans of European descent by Chibba [4]. Bidmos [5] in 2008 used following variables measured on each femur—i) vertical neck diameter, ii) upper breadth of femur, iii) epicondylar breadth, iv) bicondylar breadth, v) lateral condyle length, and vi) medial condyle length. Stature estimation was done by using regression formulae. The said study advocated that in the absence of intact femur, regression equations could provide a reliable estimate of adult stature. Research works from India by Pan[6] on Hindus of Bengal, Bihar and Orissa not only invoked research work in India, but also it drew attention beyond Indian sub-continent. In 1999,Shrof et

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al[7] conducted a research work in India and they went for calculation of the percentile length of different segments and compared those to the total length of femur to get some regression equations to estimate total length of femur from its segments and the regression coefficient found highly significant in each case. The length of femur was estimated by the equation was almost accurate with the error of ±1 cm.

In recent past, Parmar Ajay M et al[8] worked on 50 femur bones and found correlation between maximum length of femur and its proximal & distal fragments and formulated regression equation for estimation of stature from maximum femoral length in Udaipur, Rajasthan. R Umeshbabu et al[9] in their study included 50 male femurs and 50 female femurs of South Indian origin dissected from cadavers. Linear regression equations for various morphometric parameters of proximal and distal end of femur was derived to estimate length of femur and subsequently to estimate the stature of an individual.

Pavel Timonov & Antoaneta Fusova[10] conducted a study in which they introduced a method of estimating the length of femur from partial proximal elements specific to the Bulgarian population. 140 adult femora of known age and sex were studied. In that study measuring of different variables such as vertical head diameter, transverse diameter of the head, maximum head diameter, head circumference, sagittal subtrochanteric diameter, transverse subtrochanteric diameter and supero-inferior neck diameter had been done to obtain simple and multiple linear regressions. For males, regression formula, which included head circumference measurement, yielded the best result of the data, resulting in the highest correlation and lowest standard error of estimate compared with all other variables. The vertical diameter of the head of the femora of female sex showed the better correlation with maximum length. When all the variables combined into a single equation, it was found to improve the standard error of the estimate. The regression formula revealed that the femur length can be best estimated by proximal end. The derived formulae were population and sex specific.

In a research study conducted by Shweta Solan & Roopa Kulkarni [11] over south Indian populations, total number of 150, 72 left and 78 right adult fully ossified dry and processed femora were taken. After dividing each femur bone into five segments by taking predetermined points, the segmental length along with maximum length of femur were measured in cm [mean±S.D.] and the mean total length of femora of both sides were also measured. The proportion of segments to the total length were also calculated for the stature estimation using standard regression formulae. When comparison was made between segments of right and left femora, the 'p' value of points between (i) where linea-aspera divides into medial and lateral supracondylar lines and (ii) most proximal point on the intercondylar fossa was found to be ‹0.001.

In a previous study from the same State of the current study, done by Mukhopadhyay et al [12] a correlation was made between the epicondylar breadth and the maximum femoral length. In this study the total number of samples were 65. Regression equation had been applied considering the epicondylar breadth as the independent variable and the maximum length of femur as dependant variable. Eventually the result of the regression equation had been combined with the earlier population specific method of estimation of stature to formulate a new formula for stature estimation. The method of Pan for the estimation of stature from male femur was applied to the equation from that study. Multiplying factor of 3.82 was used after suitable conversion of the units (from cm to feet) of measurement to get the stature in feet from the maximum length of femur.

The present study was designed to work out a specific regression model in Eastern Indian population as regional and racial factors are found to influence the morphometrical and morphological profile of any bone.

Materials and Methods

All the 60 femur bones (fully ossified, intact, dried and devoid of any soft tissue attachments) were taken from Department of F.S.M, Burdwan Medical College, a tertiary Medical Teaching Institution of West Bengal (Eastern India). Measurements were taken using Hepburn's Osteometric Board and sliding digital caliper with a precision of 0.01mm. with an aim for estimating the total length of femur by utilizing measurements of 10 femoral fragments.

At first, all the measurements were performed by one examiner. T repeat measurement was taken by the same examiner after seven days. The two readings were then tested by paired sample t test to exclude intra-observer bias. Similarly the other two observers recorded and tested their measurements and finally the mean of the three set of readings were included in the study. Inter-rater agreement was tested with twenty five random samples by performing Cohens Kappa.

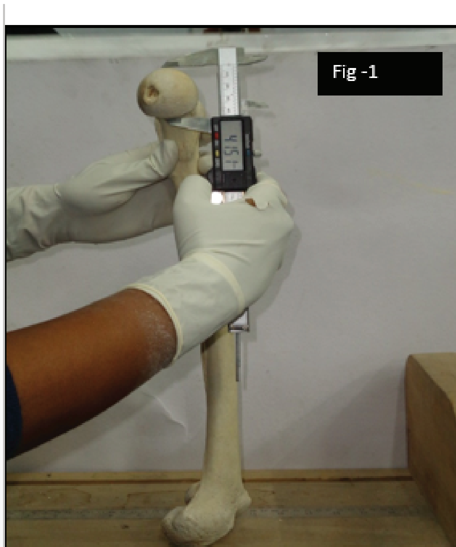
All the measurements were corrected to 2 decimal places and were recorded in cms (centimeters). Linear regression analysis was performed using Femur maximum length as the dependent variable and the fragments as predictors separately and in combination. Equations in the form of "y=mx +c" was obtained for the variables. The measurements obtained were analysed using SPSS Statistical software for windows version 10.0. The mean and S.D. of all the variables were calculated and a standard equation was derived for Eastern Indian subjects. P value of <0.05 was considered significant.

It was a Cross-sectional study where following study tools were used -measuring tape, flexible tape, dusting brush, Hepburn's Osteometric Board, Electronic Digital Caliper, pencil, OHP Marker, standard prepared master charts for Data recording.

Inclusion criteria- fully ossified, dried, processed femur bones (60 in number), irrespective of age, sex and race. **Exclusion criteria-** Unossified bones, bones with disease, injury or fragmentation.

The Femur maximum length was the linear distance measured between the most superior point on head of femur up to most inferior point on its condyles.

The femur bones were divided into 10 fragments basing upon the respective anatomical and morphological landmarks.



i. Epicondylar breadth(EB)-The linear distance measured between medial border of medial condyle and lateral border of lateral condyle.

ii. Vertical Neck diameter (VND)-the minimum diameter of the neck measured in supero-inferior direction.

iii. Transverse Neck diameter (TND)-the minimum diameter of the neck measured in AP direction.

iv. Neck Length (NL)-the distance measured between base of the head and intertrochanteric line at the junction of posterior part of neck with the shaft.

v. Vertical Head diameter (VHD)-the maximum vertical diameter of the head measured between its highest and lowest points.**(Fig: 1)**

vi. Transverse Head diameter (THD)-the maximum diameter of the head measured mediolaterally, perpendicular to the VHD.

Vii. Sub trochanteric transverse Diameter (STD):- The distance measured between medial and lateral surface at the proximal end of diaphysis at the point of its greatest lateral expansion, just below the lesser trochanter.

viii. Subtrochanteric AP diameter(SAPD)-the distance between anterior and posterior surface at the proximal end of diaphysis at the point of its greatest lateral expansion, measured perpendicular to STD.

ix. Mid-shaft AP diameter (MAPD)-the AP diameter measured at the midpoint of the diaphysis at the point of its highest elevation of linea aspera.

x. Mid-shaft transverse diameter (MTD)-measurement of the transverse diameter of the shaft which had been taken at right angles to MAPD.

Results

The fragments of femur in this study (i.e the variables) were divided into two groups .Those, that were proximal included the Head, Neck and Subtrochanteric measurements. The distal fragments consisted of MTD, MAPD and EB. Stepwise regression analysis was carried out with femoral length as the dependent variable and the two groups of fragments as independent variables. By stepwise adding and removing variables it was seen that for the proximal part only **THD** was the fragment that provided the best model that fit the data with R square of 0 .67. Similarly, for the lower fragments **EB** and **MAPD** produced the model with R square value of 0.75.

TABLE-1 & 2

MODEL SUMMARY OF REGRESSION WITH PROXIMAL FRAGMENTS				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.824	.679	.674	1.54297

Coefficientsa						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	16.535	2.221		7.444	.000
	THD (CM)	6.022	.543	.824	11.083	.000

a. Predictors: (Constant), THD (CM

a. Dependent Variable: FML(cm)

Regression Equation with proximal fragment

FEMORAL LENGTH= 16.53+6.02THD

TABLE 3 & 4

MODEL SUMMARY OF REGRESSION WITH DISTAL FRAGMENTS				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
2	.867b	.752	.743	1.36937

a. Predictors: (Constant), EB in cm

b. Predictors: (Constant), EB in cm, MAPD CM

Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
2	(Constant)	9.834	2.454		4.008	.000
	EB in cm	4.352	.335	.856	12.974	.000
	MAPD CM	-.156	.070	-.146	-2.220	.030

a. Dependent Variable: FML(cm)

Regression equation with distal fragments.

FEMORAL LENGTH=9.83+ 4.35 EB- 0.15 MAPD

TABLE -5

Descriptive Statistics Of Different Femoral Fragments					
	N	Minimum	Maximum	Mean	Std. Deviation
FML(CM)	60	34.70	46.10	41.0533	2.70131
VHD (CM)	60	3.34	4.77	4.0943	.34793
THD (CM)	60	3.30	4.79	4.0712	.36968
VND(CM)	60	2.33	3.58	2.8292	.30130
TND (CM)	60	1.83	3.12	2.4150	.30582
NL (CM)	60	2.09	3.69	2.7406	.34534
STD (CM)	60	1.90	3.40	2.8518	.32030
SAPD (CM)	60	1.90	3.18	2.3962	.32225
MAPD (CM)	60	1.90	22.09	2.9056	2.53717
MTD (CM)	60	2.00	2.79	2.3655	.19201
EB (CM)	60	6.29	8.51	7.2777	.53153

Discussions

In the present series separate regression equations were derived for the proximal and distal portion of femur to reconstruct the total femoral length from its fragments. It was seen that for the proximal end the best predictor was THD with R square of .67. This is consistent with earlier works [10,11] where the proximal fragments were useful in estimating total femoral length.

Similarly the multiple linear regression equation for the lower fragments showed consistent results with R square of 0.75. This is in agreement with previous published works [8,9,12]. The values of the various fragments are also comparable with other works on Indian population [5,7,12]

In the present study with 60 samples, the Femoral Length was considered as Dependent Variable. Correlation study was done between different segments of femur and their relationship with the FML. Among all the measured data, it was found that EB, MAPD and THD served as reliable predictors for determination of the FML from proximal and distal parts respectively. The other 7 fragmentary lengths did not reveal statistically significant results and hence discarded for the purpose of stature determination from the femur. Few previous works have however worked out regression with similar variables.

One lacunae of the present study is that the sample size is very small, consisting of only 60 femora. The present study may be considered as a pilot project aiming to obtain a regression equation for estimating maximum length of femur from different segmental parameters of femur human. As the study is region specific, it may be applied in cases associated with the local problem of identification of human remains when bony fragments or grossly mutilated bodies are encountered in medicolegal autopsies.

Conclusions

This study highlighted that a definite and reliable regression equation can be formulated for Eastern Indian population. This will be helpful for determination of Femur Maximum Length and subsequently skeletal stature from the above noted fragmentary remains among subjects belonging to the Eastern Indian population. Another notable utility of this study is that in the given population the total femoral length can be estimated by separate equations for proximal and distal fragments. This is important and will be helpful in solving practical cases when either the upper end or lower end of the femur is destroyed by animal predators or injury.

Ethical Clearance :- Taken from Institutional Ethics Committee (IEC) of Burdwan Medical College, Purba Bardhaman.

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Conflict of Interest :- Nil

Declaration

A shortened version of this study was presented by First Author as oral presentation in Forensic Medicon-2019 at Jodhpur, India , 40th Annual National Conference Of the Indian Academy of Forensic Medicine.

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