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Reconstruction of Femur Length from its Fragments

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ABSTRACT

The accurate estimation of stature helps to establish an individual's identity in medicolegal issues relating to skeletal remains examination. Stature is estimated using combined dimensions of bones responsible for living height or using regression equations based on complete long bone length measurements. In some instances like a mass disasters, these methods cannot be applied as complete long bones are not available. The aim of the present study is to derive linear regression formulae for estimating stature of adult Indian population from the fragmentary remains of femur. The study includes 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 is derived to estimate length of femur and hence to estimate the stature of an individual.

Keywords: Stature, Femur Length, Regression Equation

INTRODUCTION

Identification of an individual is the main objective of forensic investigations. Stature is considered to be one of the criteria for personal identification. Cadavers that are sent to Forensic Medicine departments are not always intact. Sometimes due to air crashes, natural disasters, explosions and other incidents, only the skeletal remains or body parts of the corpse are available for identification. Sometimes bones are crushed and only small pieces of them such as the proximal or distal ends of the bones are available In such instances it is difficult to calculate stature from bones but it still becomes more difficult to estimate the stature form fragments of bones. Previous studies show that various populations are different in size and skeletal symmetry in different races and geographical regions. If we could obtain a significant relationship between these parts and the bone length, we could predict the approximate length of the bone and consequently the approximate stature of the person.

OBJECTIVE

The objective of the present study is to estimate the length of Femur from anthropometric measurements of their fragments in south Indian population. This is important in forensic investigations and in archaeological studies particularly when the fragmentary portions are examined.

MATERIALS AND METHOD

The study is undertaken in the Department of Forensic Medicine and Toxicology, with help and support from the Department of Anatomy. One hundred pieces of adult right sided femora(50 male and 50 female), dried and fully ossified, from the Department of Forensic Medicine and the Department of Anatomy will be studied. The Pathological bones are not included in the study. It is assumed that the bones were of ethnic Indians of adult age mostly belonging to the southern parts of India. The length of the femur was measured using an osteometric board, other parameters such as maximum head diameter, breadth of both the epiphysis,inter trochanteric distance,vertical diameter of neck of femur was measured using sliding vernier callipers.

Table 1. Various femoral parameters measured

Parameters	Abbreviation	Measurement
Vertical diameter of head	VHD	Distance between the highest and lowest point of the head along equatorial plane
Vertical diameter of neck	VND	Distance between highest and lowest point of neck perpendicular to axis of the neck
Breadth of upper end femur	BUF	Distance between most superior point of fovea capitis to the most inferior point of greater trochanter
Anterior neck length	ANL	Distance between anterior inter trochanteric ridge tomid point of articular line of head of femur
Posterior neck length	PNL	Distance between posterior inter trochanteric ridge to mid point of articular line of head of femur
Inter trochanteric distance	ITD	Maximum distance between the trochanters
Epicondylar breadth	ECB	Distance between medial and lateral epicondyles of femur
Medial condylar length	MCL	Distance between most anterior and most posterior points on the medial condyle
Lateral condylar length	LCL	Distance between most anterior and most posterior points on lateral condyle

RESULTS

All the measurements showed positive degree of correlation

Table 2. Correlation of measurements of fragments of femur with length of femur

Variable	Femoral length(males)	Femoral length(females)
VDH	0.81**	0.525**
VDN	0.514**	0.506**
BUF	0.521**	0.574**
ANL	0.198^{NS}	0.195 ^{NS}
PNL	0.33*	0.455*
ITD	0.321*	0.290 ^{NS}
ECB	0.661**	0.705**
MCL	0.507**	0.513**
LCL	0.578**	0.644**

** - highly significant correlation

* - Moderately significant correlation

^{NS} No significant correlation

Table 2 shows correlation of measurements of fragments of femur with maximum length of femur. All the variables showed positive correlation with length of femur. VDH showed highest degree of correlation and VDN showed lowest degree of correlation in males. In females ECB shows highest degree of correlation and VDN showed lowest degree of correlation . ANL, PNL and ITD showed no significant correlation.

Table 3 Shows Regression analysis from individual independent variable.

Regression Equation (males)	Regression Equation (females)
35.85+(2.094)VDH**	25.325+(3.907)VDH**
35.34+(3.081)VDN**	27.608+(4.597)VDN**
33.33+(1.31)BUF**	22.097+(2.351)BUF**
44.077+(0.295)ANL ^{NS}	37.209+(0.915)ANL ^{NS}
44.72+(0.107)PNL ^{NS}	33.389+(2.063)PNL*
41.43+(0.533)ITD ^{NS}	36.514+(0.595)ITD ^{NS}
21.91+(3.052)ECB**	30.368+(1.451)ECB**
26.17+(3.111)MCL**	25.045+(2.933)MCL**
34.377+(1.806)LCL**	29.43+(1.326)LCL**

** - highly significant correlation

* - Moderately significant correlation

^{NS} No significant correlation

Linear regression analysis

Table 3 shows bivariate regression analysis for estimation of maximum length of femur from femoral fragments. The linear regression analysis between femoral length and femoral fragments inboth the sexes was found significant for a majority of variables except for ANL, ITD and PNL in males and ANL and ITD in females. The highest correlation for an individual measurement was obtained for VDH and ECB in males and for females highest correlation was obtained for ECB and LCL

CONCLUSION

This paper has presented analysis of some metric data from proximal and distal end of femur for correlation with maximum length of femur. Our study has positive correlation for majority of variables. Hence when fragments of femur are available to estimate stature, maximum length of femur can be calculated with a reasonable accuracy with metric evaluation of these fragments and hence stature can be estimated. The primary message in the present study is that different geographic regions require their own stature estimation criteria and the criteria derived from studies from other geographic regions cannot be applied to them. Ethnical variations require further population specific studies of estimation of stature from fragmentary remains of femur.

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Table 4. Regression equation to determine femur length using proximal end of femur

Males
34.85+2.96(DN)+0.370(VDH)**
32.549+2.79(DN)+0.13(VDH)+0.35(BUF)**
31.93-0.41(VDH)+2.94(DN)+0.56(BUF)+0.47(ANL)-0.27(PNL)*
31.746+0.196(ITD)-0.48(VDH)+2.904(DN)+0.486(BUF)+0.523(ANL)-0.346(PNL) NS
Females
22.653+1.959(DN)+3.215(VDH)**
19.52+1.564(BUF)+1.339(VDH)+1.317(DN)**
19.792+0.564(PNL)+0.265(ANL)+1.116(BUF)+1.445(VDH)+1.367(DN)*
20.256+0.595(PNL)+0.219(ANL)+1.160(BUF)+1.475(VDH)+1.264(DN)-0.102(ITD) NS

Table 5 - Regression equation to determine femur length using proximal end of femur

Males
17.169-0.626(LCL)+2.724(MCL)+2.045(ECB)*
Females
32.105+1.189(ECB)+5.451(MCL)-5.546(LCL)*

Multiple regression analysis.

The degree of correlation between length of femur and various combinations of measurements of upper end and lower end of femur for males and females is given in tables 4 and 5. The equations are arranged in descending order of correlation. In both genders VDH, VDN and BUF showed highest correlation in combination for upper epiphysis whereas ECB alone showed better correlation than combination in lower epiphysis

DISCUSSION

Stature is often an important piece of information when creating a biological profile for personal identification of an unknown individual. As evident from previous studies, femur is the most accurate single bone for stature estimation probably because it contribute most to the living height [1]. Estimation of stature requires full length of long bones which is not available in some instances as mentioned in introduction. Hence in such instances length of femur may be estimated based on its fragments and later employ them in stature estimation formulae to get reasonably accurate results.[2]Muller made the first attempt in estimating the maximum length of a long bone from measurements of its sections. Steele and McKern studied on femur to delineate it into sections as suggested by Muller. Simmons etal reported difficulty in reproducing the measurements as M.Chandran[2] and Bidmos [3]have shown significant correlations between femoral fragments and maximum length of femur.

Femoral fragments measured on dry bones in this study have an overall low correlation with the length of femur compared to the study by M.Chandran and Bidmos. Correlation between femoral fragments and femoral length ranged from 0.811 to 0.618 in M.Chandran's study and 0.781 and 0.400 in Bidmos study compared to 0.815 and 0.455 in the present study. There are several possible reasons for the difference between the results of these studies. It can be due to difference in the method used to measure the variables, inter observer bias, difference in sample size, difference in mean age of the sample, ethnical difference, ancestry etc. Inter observer error has the potential to increase the variation in data. To reduce this inter observer error, the measurements were taken by two individuals and mean of the values are taken in the present study. Sample characteristics like age may also be the reason for the difference in the results as loss of stature is said to begin around 30 years of age. The mean age in Bidmos study was 58 and 62 years for males and females respectively, whereas in the present study age of the sample is not known.

In the present study VDH and ECB in males and ECB and LCL in females showed better correlation with femur length. Whereas in M chandran's study FDL and MCL had best correlation with femoral