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Estimation of Length of Femur from Morphometric Measurements of Its Distal Fragments in South Indian Population.

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ABSTRACT

Estimation of the stature is an important aspect in any medico-legal investigation. Stature is usually estimated by employing either anatomical or mathematical methods. . Mathematical method is better than anatomical method because it can be used to estimate stature by using single bone or bone fragment, as in most of the times complete skeleton is not available. Total skeletal height or living stature is estimated by use of bone length, stature table and regression formula. The aim of the present study was to examine the correlation between maximum length of femur and its distal fragments in south Indian population. Maximum femoral length and measures of four distal fragments of 280 femora (140 right and 140 left) were obtained by means of osteometric board and sliding calipers and regression equations were formulated to calculate length of femur. . All the fragmentary measurements in our study showed positive correlations with the femoral length.

Keywords: Stature estimation, Femur, Distal fragment, Regression equation, South Indian population.

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INTRODUCTION

Estimation of the stature which is an important aspect in any medico-legal investigation is usually estimated by employing either anatomical or mathematical methods. Anatomical method, more commonly referred to as the "Fully method", reconstructs stature by summing the measurements of the skeletal elements cranial height, vertebral height, femoral length, tibial length, and the articulated height of calcaneus and talus that contribute to height and adding a correction factor for soft tissue . The other known method is mathematical method which makes use of one or more bone lengths to estimate the stature [1]. Mathematical method is better than anatomical method because it can be used to estimate stature by using single bone or bone fragment, as in most of the times complete skeleton is not available. Total skeletal height or living stature is estimated by use of bone length, stature table and regression formula.

Different bones have been used in the estimation of stature. The conventionally used bones for stature estimation are the long bones (femur, tibia, fibula, humerus, ulna, radius), but the short bones of the hand and feet may also be used. Individually and collectively, the femur and the tibia are the most important components of stature. In humans, femur is the longest and largest long bone which has the highest correlation with stature in intact state. Therefore the best assessment of stature is obtained from the regression formula derived from femoral length [2,3]. Bone and stature of an individual is influenced by age, sex, race, geographical climate, nutrition and genetic factors. Hence, the correlation factors of one region will not hold good for the other, as this necessitates the researches to be done on regional basis [4]. Systematic use of regression formulae obtained in a specific population can under or overestimate stature, when applied in another population. Thus, authors have recommended that regression formulas obtained in a certain population should not be applied to the other [5].

Fragments of long bones (because of injuries, mutilation, destruction, post mortem gnawing by wild animals) are often presented as only available identity and subsequently stature estimation from the fragments available by the use of regression equation becomes necessary [6].

The morphometric values of femoral segments is is also helpful for the clinicians in the treatment of proximal and distal femur fractures [7].

Hence the present study was designed to examine the correlation between maximum length of femur (FML) and its distal fragments in 280 dry bones and to derive a population specific and sex specific formula (regression equation) to estimate the length of femur from its fragments in South Indian population.

MATERIAL AND METHODS

Data for the present study comprises of 280 femora (140 male – 70 right, 70 left and 140 female – 70 right, 70 left) of South Indian origin from Anatomy department of Sri Siddhartha Medical College, Tumkur, Karnataka.

For the measurements of Maximum femoral length, an osteometric board was used. The measurements of distal fragments were obtained by means of sliding calipers. Each measurement was made thrice by the same examiner and the mean value was considered.

FML – Maximum Femoral Length – linear distance between the most superior part of head of femur and most inferior part of medial condyle. Instrument used – Osteometric board

BCB – Bicondylar Breadth. From the most lateral and posterior projection of the lateral condyle to the most medial and posterior projection of the medial condyle. Instrument used – sliding calipers

ECB – Epicondylar Breadth.--The linear distance between the most projected points on the epicondyles. The measurement is taken at right angle to the shaft axis. Instrument used – sliding calipers.

MCL – Medial Condyle Length. The linear distance between the most anterior and the most posterior points on the medial condyle. Instrument used – sliding calipers.

LCL –Lateral Condyle Length. The linear distance between the most anterior and the most posterior points on the lateral condyle. Instrument used – sliding calipers.

Data was subjected to relevant statistical analysis to formulate regression equations to reconstruct femoral length from its distal fragments.

RESULTS

Table 1 and 2 shows mean values of maximum femoral length (FML) and its distal fragments (right and left sides) in males and females respectively. Statistical test for analysis of differences between right and left sides was accomplished.

It is apparent from table 1 that bilateral difference was insignificant in the right and left femora in males at p<0.05 level of significance except for BCB.

Table 2 depicts that bilateral difference was insignificant in the right and left femora in females at p<0.05 level of significance except for FML.

Table 3 presents Karl Pearson co-efficient of male femora which range between 0.726 and 0.314 for right side and 0.596 and 0.145 for left side.

Table 4 presents Karl Pearson co-efficient of female femora which range between 0.490 and 0.287 for right side and 0.506 and 0.379 for left side.

Tables 5 & 6 represents linear regression equations for reconstruction of femoral length from distal fragments in male and female femora.

Multiple regression formulae for calculation of FML from the measurements of distal fragments of femur are as followed:

Right male femur - FML = 19.434 + 2.837 BCB + 0.373 ECB – 0.681 LCL + 1.049 MCL
Left male femur - FML = 23.004 + 0.086 BCB + 2.638 ECB + 0.319 LCL - 0.076 MCL
Right female femur - FML = 20.440 – 0.191 BCB + 2.603 ECB + 0.369 LCL + 0.346 MCL
Left female femur - FML = 26.725 – 0.319 BCB + 1.358 ECB + 1.298 LCL + 0.145 MCL

Table 1: Comparision of bilateral measurements of male femora.

Male Femur		Right		Left		p value
		Mean	SD	Mean	SD	
1	FML	44.99	2.54	45.01	2.42	0.97
2	BCB	7.22	0.55	6.99	1.03	0.02
3	ECB	7.71	0.43	7.59	0.52	0.37
4	MCL	5.64	0.69	5.57	0.75	0.50
5	LCL	5.44	0.94	5.68	0.68	0.09

Table 2: Comparision of bilateral measurements of female femora.

Female Femur		Right		Left		p value
		Mean	SD	Mean	SD	
1	FML	40.97	2.26	41.67	2.17	0.01
2	BCB	6.38	0.46	6.38	0.59	1.00
3	ECB	6.92	0.44	6.97	0.51	0.61
4	MCL	5.07	0.54	5.07	0.68	1.00
5	LCL	5.10	0.74	5.21	0.60	0.33

Table 3: Karl Pearson co-efficient and p value in the correlation between maximum length and fragments of male femora.

Characteristics		Karl Pearson's co-efficient	p value
FML-BCB	Right	0.726683	0.001
	Left	0.316285	0.007
FML-ECB	Right	0.678063	0.001
	Left	0.596489	0.001
FML-MCL	Right	0.469559	0.001
	Left	0.145459	0.229
FML-LCL	Right	0.314371	0.008
	Left	0.205017	0.088

Table 4: Karl Pearson co-efficient and p value in the correlation between maximum length and fragments of female femora.

Characteristics female		Karl Pearson's co-efficient	p value
FML-BCB	Right	0.49099	0.001
	Left	0.379459	0.001
FML-ECB	Right	0.535116	0.001
	Left	0.432161	0.001
FML-MCL	Right	0.357448	0.002
	Left	0.435219	0.001
FML-LCL	Right	0.287525	0.015
	Left	0.506785	0.001

Table 5: Regression Equations for reconstruction of femoral length from distal fragments (male).

Right Males	**Left Males**
FML= 20.95 + 3.33 BCB ± 2.76	FML= 39.81 + 0.74 BCB ± 1.92
FML= 14.24 + 3.99 ECB ± 4.40	FML= 23.76 + 2.80 ECB ± 3.52
FML= 40.38 + 0.84 LCL ± 1.71	FML= 40.84 + 0.73 LCL ± 2.44
FML= 35.30 + 1.71 MCL ± 2.23	FML= 42.40 + 0.46 MCL ± 2.17

Table 6: Regression Equations for reconstruction of femoral length from distal fragments (female).

Right Females	**Left Females**
FML= 25.64 + 2.40 BCB ± 3.30	FML= 32.69 + 1.40 BCB ± 2.68
FML= 22.16 + 2.70 ECB ± 3.64	FML=28.84 + 1.83 ECB ± 3.29
FML= 36.46 + 0.88 LCL ± 1.83	FML= 32.02 + 1.84 LCL ± 2.01
FML= 33.31 + 1.50 MCL ± 2.43	FML= 34.64 + 1.38 MCL ± 1.79

Table 7: Comparision of mean values of distal femoral fragments of the present study with others.

Study	ECB		BCB		LCL		MCL	
	MEAN	S.D	MEAN	S.D	MEAN	S.D	MEAN	S.D
Bidmos SED males	8.07	0.42	7.60	0.33	6.52	0.35	6.53	0.37
Bidmos ISA males	7.87	0.40	7.49	0.46	6.47	0.36	6.45	0.37
Bidmos SED females	7.22	0.39	6.74	0.41	6.30	0.35	5.95	0.32
Bidmos ISA females	6.99	0.50	6.66	0.50	5.98	0.41	5.78	0.76
Chandran M	6.6	0.3	6.1	0.3	5.4	0.3	5.2	0.3
Present study Rt. Males	7.71	0.43	7.22	0.55	5.44	0.94	5.64	0.69
Present study Lt.male	7.59	0.52	6.99	1.03	5.68	0.68	5.57	0.75
Present study Rt.female	6.92	0.44	6.38	0.46	5.10	0.74	5.07	0.54
Present study Lt. Female	6.97	0.51	6.38	0.59	5.21	0.60	5.07	0.68

SED-South African of European descent, ISA-Indigenous South

DISCUSSION

Identification of an individual by stature estimation has profound significance in civil and criminal cases from the medico-legal view of point.

Estimation of stature from bones has anthropological and forensic importance. As compared to Fully's method, regression analysis is a more appropriate method to define relationship between length of long bones and living height of individuals and between length of measurements of long bone fragments and their maximum length.

Muller appears to be the pioneer in studying the mean proportions of various parts of some long bones like Tibiae, Humerii, and radii to their total length [8].

Karl pearson was the first person to develop stature regression formula [9].

The linear regression equations to calculate stature from length of bones have been cited in 'Human Skeleton in Forensic Medicine' [10].

Many workers like Trotter and glosser [11] estimated the stature from length of long bones.

Gorden and Drennan successfully reconstructed total length of Humerus and femur from available fragments of bones [12]

Studies were done in different races by Bidmos on South african population who presented the regression equations for stature estimation by measuring 6 fragments of Femur which includes vertical veck diameter, upper breadth of femur, epicondylar breadth, bicondylar breadth, lateral condyle length, and medial condyle length [13].

However the statistical formula used in this method is appropriate when used only in specific population whence it was derived. Individual height is influenced by ethnicity, so it is recommended that regression formulae obtained in certain population should not be applied in another. Regression formula obtained in a specific population can underestimate or over estimate stature if applied in another population. Such population specific studies were done by Stevenson on northern Chinese male skeletons [14] and dupertain and haddenon on American whites and blacks [15].

India is characterized by wide variation in anthropometric dimensions among its population types. This necessitates the study in a more localized way to establish specific osteometric standards for different regions in India.

Studies on Indian population like Pan [16] on Hindus of Bengal, Bihar and. Kate and Mazumdar[17] are noteworthy.

Shwetha solan [7] and Chandran M [18] reconstructed the femoral length by using fragments in south indian population.

Peterson has considered that in most studies only a small number of skeletons are available for analysis [19]. The sample size used in present study was better for establishing a relationship between long bone length and stature.

The present study is also a population specific and sex specific study and the regression equation derived is specific for South Indian population.

Most of the previous studies done on femoral fragment measurements were done irrespective of the side of femur bone. In the present study, the mean total length of femur and its segments was calculated separately for right and left sides.

In the study, we used the precise landmarks, Maximum femural length(FML) and four measurements (BCB,ECB,MCL,LCL) of the distal end were identified and selected in a sample of 280 adult femora.

While considering the descriptive statistics, mean value of FML in South Indian males varied from 44.99 (right) to 45.01(left). In females FML was 40.97(right) to 41.67(left).These values correlated with those of Sarzoo (43.71)[20], Sandeep (43.75) [6], Chandran M (39.5) [18] and Shwetha Solan (Rt- 43.42 & Lt – 43.54) [7].

While considering the descriptive statistics as in table 7, the mean values of most of the comparable measurements in Bidmos study are more than that of our study ,this is attributed to the fact that people from Indian origin are shorter than the South African population sample considered by them. Mean values of FML, BCB, ECB,LCL,MCL of South Indian female population were well correlated with that of study conducted on a similar population by Chandran M.

Correlation is a measure of association between two variables. In our study correlation of maximum length of femur with it,s distal fragments were calculated in both the sexes bilaterally. All the measured variables displayed positive correlation with the FML.

In the present study, amongst right male femora BCB had maximum correlation with FML, where as in the left femora maximum correlation was shown by ECB. (Table-3)

But in female femora ECB and LCL had maximum correlation in Right and left sides respectively. It differs from Chandran M study in which MCL had maximum correlation.

In the present study, male femora showed higher mean values compared to female Femora for FML and all fragmentary measurements which infers sexual dimorphism of these femoral dimensions supporting previous studies on stature estimation. Since all the measurements in our study had positive correlation with the FML, it is prudent to derive simple linear regression by regression analysis against the individual measurements to calculate FML from anyone of these markers . (Tables 5 and 6).

The order of reliability from the distal fragments in South Indian male Right Femora is from BCB,ECB,MCL and LCL successively whereas in Left Femora it is ECB,BCB,LCL and MCL.

In South Indian female population among the Right Femora, the order of reliability is ECB, BCB, MCL,LCL where as in Left Femora it is LCL, MCL, ECB and BCB.

CONCLUSION

Regression equations were derived for estimation of maximum femoral length from measurements of distal fragments of the femur among South Indian population. All the fragmentary measurements in our study showed positive correlations with the femoral length. Therefore the maximum femoral length can be estimated from fragmentary remains of distal ends of femur. In the absence of intact long bones, equations presented in this study can offer a reasonable estimate of maximum femoral length from which the stature can be estimated in sex and population sample [21].

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