Estimation of Stature from Radiological Length of Femur among South - Indian Adult Population

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ABSTRACT

Introduction: Stature estimation by analyzing skeletal remains or body parts is an essential part of human identification. One critical role of stature estimation today lies in the forensic identification of crime victims and missing persons. Femur, being the longest and strongest bone in the body, plays a crucial role while estimating stature of an individual. In this study, we tested a new approach to predict the stature of a person by radiologically measuring the femur length.

Material and methods: Our study was conducted on 100 South Indian subjects (50 males and 50 females) with an aim of obtaining regression formulae for estimation of stature of males and females, from maximum femur length and another individual sample consisting of 20 male and 20 female participants belonging to the same criteria as the preliminary subject group was used for validating the obtained equations.

Results: It was observed that femur length showed statistically significant correlation with stature in both the groups (p=0.0001). Regression equations specific to geographical (South-Indian) population were statistically analyzed for femur lengths in males (r=0.880) and females (r=0.862) and significantly proved reliable in estimating the living stature of an individual.

Conclusion: In our study, the mean stature value of males was higher than that of females contributing to the inference that males are generally taller than females.

Keywords: Anthropometry, Femur Length, Forensic Radiology, Human Identification, Stature etc.

INTRODUCTION

Anthropometry has a prime role to play in the identification of human materials in the field of forensic anthropology. The estimation of stature from extremities forms an integral part in the process of identification of deceased individuals and it has been observed that dimensions from the lower extremity of the body have greater association with body height than those from the upper extremity.[1]

Within specific population groups, the body ratios change overtime due to changes in diet, lifestyle and socio-economic status. This means it is necessary to periodically verify equations viewing to fix height when alive.[2] However, lack of up-to-date information on the population groups of South India makes estimation of stature from bones in this area subject to possible error. It is essential to fill this lacuna in order to achieve more accuracy in stature estimation, which directly shall aid in achieving the goal of personal identification.

Femur invariably is one of the long bones that constitute greatest proportion of stature. Nevertheless, it plays a crucial role while estimating stature of an individual. Regression analysis is a more appropriated method to define relationships between length of long bones and living height of individuals, and between length of measurements of long bones fragments and their maximum length.[3] This study aimed to obtain regression formulae for estimation of height of males and females, from maximum femur length determined radiologically, and to assess their validity in different stature categories-short, medium and tall.

MATERIAL AND METHODS

100 South Indian subjects- 50 males and 50 females, aged above 19 years and below 45 years, referred to the Radio-diagnostics Department, SSIMS and RC, Davangere were selected after taking written informed consent. Subjects with fracture, pathology and congenital anomalies were not included in this study. Another individual sample consisting of 20 male and 20 female participants belonging to the same criteria as the preliminary subject group was used for validating the obtained equations.

The procedures, aims and objectives of the study were explained individually before taking stature measurement, X-ray imaging of the femur and radiological measurement of length of femur. Stature was measured with the subject standing with his bare feet and back to anthropometer and with the head adjusted such that the Frankfurt plane (upper border of the external auditory meatus is on a horizontal plane with the lower border of the eye) was parallel to the headboard.[4]

Radiological measurement of femur length was done by X-ray imaging of either of their left or right femur bones. The true maximum length of femur was measured on the AP

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viewofthe X-raydigitalimageasthemaximumdistancefrom theuppermostmarginofthehead of the femur to the lowest margin of the medial condyle[4], as demonstrated in Figure 1.

STATISTICAL ANALYSIS

The data obtained was analyzed using SPSS for Windows 7 as follows: unpaired and paired t-tests, linear regression analysis and ANOVA. Regression formulae were obtained separately for male and female group. Pearson's correlation coefficient and standard error of estimate were obtained.

RESULTS

The study group included 50 males and 50 females, aged above 19 years and below 45 years with the mean age of 28.22±7.72 years in males and 29.16±8.751 years in females. The mean age differences between the sexes were statistically insignificant.

The mean stature value of males being 170.22 ± 6.726cms and females 159.96 ± 6.928cms, with statistically significant difference (p=0.0001). The mean femur length in males was 45.732 ± 2.352 cms and in females 43cm with statistically significant difference (p=0.0001)

Pearson's correlation coefficient between stature and femur length in males and females showed that femur length is statistically significant in correlation with stature in both the groups. Table 1.

Table 2 shows the regression equations for stature (in cms) that were obtained from the data. The equations have been expressed as a linear equation y=ax+b, where y is the dependent variable i.e. stature while x is the independent variable i.e., femur length. The constants a and b are regression coefficients of femur length and stature respectively. Also, the table shows that the standard error estimate (SEE) values for males were 8.979 while that for females was 8.996.

Table 3 shows the percentile distribution of stature and femur lengths. The cut offs were placed at 25th and 75th percentile. The lower 25% was considered short, upper 25% considered tall while middle 50% was considered medium, under categories for bone length.

The comparisons of actual stature and estimated stature from the regression formulae obtained in the study for different bone length categories showed statistically

Group	Pearson's correlation coefficient (r)	p
Males; N=50	0.880	0.0001
Females; N=50	0.862	0.0001
p value < 0.05 = statistically significant.		

Table-1: Correlation coefficients between stature and radiologically determined femur length in South Indian adults.

Group	Regression equation	R2	See
Males	Stature = 55.16 + 2.51 x Femur length	0.774	8.979
Females	Stature = 53.89 + 2.52 x Femur length	0.744	8.996
SEE= Standard error of estimate.			

Table-2: Regression equation formulae for males and females where stature and femur length are in cm.

Figure-1: Radiographic digital image showing AP view of right femur of a female- maximum femur length being measured from uppermost margin of head to lowermost margin of medial condyle.

	Males		Females	
Percentile distribution	Stature	Femur length	Stature	Femur length
25th	165	43.875	155.75	40.425
75th	177.25	47.85	166	44.15

Table-3: Percentile distribution of stature (cm) and femur length (cm) with cut offs at 25th and 75th percentile.

Group	Bone length category	Actual Stature Mean + S.D.	Estimated stature from formula Mean + S.D.	Difference Mean + S.D.	p value
Males (N=20)	Short (N=5)	161.8 + 2.68	161.88 + 4.18	-0.08 + 1.5	0.475 NS*
	Medium (N=10)	169.4 + 3.86	169.24 + 4.17	0.26 + 0.31	0.355 NS*
	Tall (N=5)	178.2 + 0.83	177.99 + 1.57	0.21 + 0.74	0.409 NS*
Females (N=20)	Short (N=5)	153.50 + 2.38	152.12 + 2.55	1.38 + 0.17	0.018**
	Medium (N=10)	160.2 + 3.79	160.23 + 3.26	0.03 + 0.53	0.468 NS*
	Tall (N=5)	169.2 + 2.28	168.7 + 1.86	0.5 + 0.42	0.193 NS*
S.D = Standard deviation. *NS= Not significant **p<0.05 = significant.					

Table-4: Comparison between mean of actual stature and the stature estimated from obtained formulae in different categories of bone length: short, medium and tall

insignificant values in all cases, except for short bone length category in females (Table 4).

DISCUSSION

In forensic anthropology, living (forensic) stature is among the four major categories of the basic biological profile: sex, age, ancestry and stature.[5,6] In the present study, living stature was taken into account as Trotter and Gleser's study said that it isn't possible to give a definite correction factor to cadaveric stature, due to various factors- like time between death and measurement etc.[7] Researchers and anthropologists have scrutinized various bones of the body to check their potentiality for use in estimation of stature – long bones, clavicle, skull, scapula, oscoxa, vertebral column, calcaneus, hand and foot dimensions, metatarsals and even just fragments or sections of long bones.[5] In our study, we choose the femur and tested a new approach to predict the stature of a person by radiologically measuring the femur length. In this study, there was a significant finding that mean stature value of males was higher than that of females. This contributes to the inference that males are generally taller than females, which is in agreement with previous observations made by Dayal et al[8] and Sheta et al.[4]

Also, it was found that mean values of femur lengths in males and females showed statistically significant differences. It was inferred that there is certain sexual dimorphism for the measured femur lengths, as the mean values for males were higher than those of females. Hence, maximum femur length can also be used as a tool for sex interpretation, as confirmed previously in findings of other studies by Hauser et al[9] and Mall et al.[10] It was found in this present study that femur length shows a highly statistically significant correlation with stature.($r=0.88$ in males and $r=0.862$ in females).

The present study also attempted to validate the derived regression formulae using another independent sample of 40 subjects (20 males, 20 females), who were categorized into short, medium and tall, depending on bone length. It was found that the differences in means of actual stature and the stature estimated from these formulae were insignificant in all categories, except for the short bone length category (n=5) in females. This is suggestive of the fact that the reliability of these equations for short women of this area must be improved. This can be done by validating the formulae or providing adjustment factors by doing a study on large scale for this category.

CONCLUSION

The research consisted of a primary study sample of 100 subjects (50 males, 50 females) and a secondary subject sample of 40 participants (20 males, 20 females). The primary objective was to derive regression formulae for stature estimation from 100 South Indian subjects. This was done by determining femur length radiologically after subjecting the participants to X ray imaging (after explaining the procedure and aims and obtaining written consent). The actual height of these subjects was also measured. The data obtained was analysed using linear regression and two separate formulae were obtained for males (Stature= 55.16 + 2.51x Femur length) and females (Stature= 53.89 + 2.52x Femur length). The present study has established a significant correlation between stature and femur length. It also attempted to check the validity of the formulae obtained by regression analysis. There was a limitation of reliability of these equations for short women, so it is recommended to validate the formulae or provide adjustment factors to study on large scale for this category

The results are described and significant findings that came up were- the femur is a reliable long bone for stature estimation, males are generally taller than females and that there was significant correlation between femur length and stature.

Regression models must be developed from time to time as stature of individuals may vary across time due to various factors- nutrition, socioeconomic status etc. Although the field of forensic medicine has had tremendous advancements, identification techniques need periodic review. Practical use of regression equations obtained in this model will immensely help in establishing identity of missing persons, highly decomposed bodies, bodies obtained in mass disasters, accidents etc. where only lower limbs might be intact, and also in some civil cases. The equations may vary for different races, age groups and for different population groups. Hence this kind of study must be conducted on a large scale, to achieve higher accuracy in the ultimate goal of the identification process.

Ethical clearance

Taken from Institutional Ethics Committee, SSIMS and RC, Davangere.

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