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Estimation of Stature from the Percutaneous Length of the Tibia, Ulna and Radius in South Indian Population

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ABSTRACT

Background: Stature estimation is one of the important parameter in establishment of the identity of a person. It is important to establish studies in different populations as stature varies in different races and populations.

Material and methods: In the present study, an attempt has been made to estimate stature from the lengths of tibia, radius and ulna in 100 medical students belonging to South Indian population. Linear and multiple regression equations were calculated for estimating stature from the lengths of tibia, radius and ulna.

Results: In males, correlation coefficients of the linear regression equations ranged from 0.714 to 0.630 with standard error 4.93 to 5.47 cm. Whereas, in females it ranged from 0.661 to 0.560 with standard error 4.12 to 4.55 cm. Multiple regression equations involving all the three parameters showed higher correlation coefficients (0.829 in males and 0.747 in females) with standard error 4.02 cm in males and 3.73 cm in females. **Conclusion:** The regression equations of the present study are helpful in estimating stature from the lengths of tibia, radius and ulna in South Indian population.

Keywords: Forensic anthropology, identification, stature, dismembered body, limb length.

INTRODUCTION

Identification of a victim or an accused involved in a criminal act is an important task in the field of forensic investigation. Estimation of stature of an individual from the skeletal materials or from the mutilated or amputated limbs or parts of the limbs has obvious significance in the personal identification in the events of the murders, accidents or natural disasters that mainly concerns with the forensic identification analysis.

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Many studies have been conducted in different ethnic groups to estimate stature from the length of long limb bones, because the long limb bones have got a definite correlation to the height of an individual.[1-8] Few studies have been proved that the percutaneous measurement of long limb bones are useful in the estimation of living stature.[9-12] However, stature varies with the race and is determined by genetics of a person, geographical location, environment and climatic conditions. Since no studies have been documented in the South Indian population, an attempt has been made to estimate stature of an individual from percutaneous lengths of the radius, ulna and tibia in South Indian population.

MATERIAL AND METHODS

The study sample includes 100 MBBS students (both males and females) belonging to South India studying in Father Muller Medical College,

Mangalore in the age group of 18-24 years. The informed consent was taken from the subjects before taking the measurements. The subjects with any congenital deformities, trauma and pathological conditions affecting the height of a person and of the right upper and lower limbs were excluded from the study.

Height of the subject was measured in standing position using stadiometer. The subjects were asked to stand barefooted on the board of a standard stadiometer with both feet in close contact with each other, trunk braced along the vertical board, and the head adjusted in Frankfurt plane. The measurement was taken in centimeters, by bringing the horizontal sliding bar to the vertex. Then, the length of tibia, ulna and radius was taken using Vernier caliper. To maintain uniformity, only the bones of right side were considered for the study.

Length of tibia

Ask the subject to sit straight with thigh in a straight line, knee flexed at 90° position and the foot rotated laterally, which makes the bony projections prominent. Then, length of the tibia was measured as a straight distance between the superior-most margin of the medial condyle to the inferior-most margin of the medial malleous.

Length of ulna

Ask the subject to sit in straight position and flex the elbow at 90° with arm parallel to ground. Rotate the wrist completely (in complete pronation) which makes the styloid process of the ulna prominent. Then, the length of ulna was measured as a straight distance from the most proximal point of the olecranon process to the most distal point of the styloid proces.

Length of radius

Ask the subject to sit straight with the elbow semi-flexed, and the forearm and hand in straight position. Then, length of the radius was measured as a straight distance between the superior-most point on the outer surface of radial head to the most distal point of the styloid process.

Statistical analysis

The data was analysed using Statistical Programme for Social Sciences (SPSS) version 11. The linear and multiple regression equations were derived for estimating stature from individual bones and for the combination of bones, respectively. For assessing the correlation between the stature and the length of the bones, the Pearson's correlation coefficient was calculated and its significance was tested by Students-t test. "P" value less than 0.05 was considered as significant.

RESULTS

The study sample consists of 50 males and 50 females. Age of the study population ranged from 18 to 22 years in both sexes with the mean age of 19.80±1.21 years in males and 19.34±0.87 years in females. Stature of the study population ranged from 153.20–192.00 cm (173.61±6.97 cm) in males and 152.40–178.40 cm (163.04±5.43 cm) in females. Descriptive statistics of the study sample were shown in Table 1. Length of tibia, ulna and radius were larger in males compared to females. The linear regression equations for the estimation of stature from the lengths of tibia, ulna and radius were shown in Tables 2 and 3. The highest correlation coefficient was observed with tibial length in both sexes (0.714 in males and 0.661 in females). Among the forearm bones, higher correlation coefficient was found with radial length in males and ulnar length in females. Multiple regression equations (Table 4) were calculated using all the parameters, which improved the correlation coefficients in both sexes (0.829 in males and 0.747 in females).

DISCUSSION

Estimation of stature from bones plays an important role in identifying unknown bodies, parts of bodies or skeletal remains. In the present study, an attempt has been made to estimate the stature from the lengths of tibia, radius and ulna in South Indian population.

In the present study, the mean stature of male sample is 173.61±6.97 cm in males and 163.04±5.43 cm in females. This differs from other studies conducted in Eastern and Northern parts of India,[9,10] Mauritius,[11] Germany,[5] Turkey[4,12] and Korea[13] where the stature was lower compare to the South Indians. Similarly the length of tibia, radius and ulna was also varies in different populations (Tables 5 and 6). The above observations are in concurrence with the fact that stature varies in different races and populations. However, on should not forget that these differences could be due to variation in techniques adopted while measuring these parameters.

Linear regression equations were calculated for each measurement. The correlation coefficients of the linear regression equations ranged from 0.714 to 0.630 in males and 0.661 to 0.560 in females. The standard error of estimate ranged from 4.93 to 5.47 cm in males and 4.12 to 4.55 cm in females. Multiple regression equations were calculated by including all the three measurements, which showed improvised correlation coefficients (0.829 in males and 0.747 in females) with standard error of estimate 4.02 cm in males and 3.73 cm in females. This is comparable to other studies conducted in Eastern and Northern India,[9,10] Mauritius,[11] Turkey[4,12] and Korea[13] (Tables 5 and 6). However, the study on German population showed high standard errors for stature estimation from the lengths of radius and ulna.[5] The highest correlations were observed between the stature and tibial length, which explains that the weight bearing bones are better indicators of the stature.

We conclude that there is a linear relationship between the length of bones and body height. The lengths of tibia, radius and ulna could be helpful to estimate stature. The regression equations of the present study could be used to estimate stature in South Indian population.

Table 1: Descriptive statistics of the study sample

Parameter	Male			Female		
	Min	Max	Mean	Min	Max	Mean
Age (years)	18.00	22.00	19.80±1.21	18.00	22.00	19.34±0.87
Stature (cm)*	153.20	192.00	173.61±6.97	152.40	178.40	163.04±5.43
Tibial length (cm)*	37.90	51.00	42.24±3.04	35.60	44.60	39.43±0.30
Ulnar length (cm)*	25.00	34.40	29.02±1.69	24.40	30.90	27.64±0.19
Radial length (cm)*	22.50	31.10	26.73±2.07	21.90	26.80	24.33±0.17

* Difference between male and female is significant ($p<0.05$)

Table 2: Linear regression equation for estimating stature in males

Parameter	Equation	SE (cm)	R	R^2
Tibial length	H = 1.636y + 104.484	4.931	0.714	0.510
Ulnar length	H = 2.575y + 98.876	5.500	0.625	0.390
Radial length	H = 2.124y + 116.836	5.471	0.630	0.397

H- Height (cm); y- Length of the bone (cm); SE- Standard error of the estimate (cm); R- Correlation coefficient.

Table 3: Linear regression equation for estimating stature in females

Parameter	Equation	SE	R	R^2
Tibial length	H = 1.670y + 97.19	4.118	0.661	0.437
Ulnar length	H = 2.427y + 95.555	4.371	0.605	0.366
Radial length	H = 2.528y + 101.515	4.550	0.560	0.313

H- Height (cm); y- Length of the bone (cm); SE- Standard error of the estimate (cm); R- Correlation coefficient.

Table 4: Multiple regression equations for estimating stature

Sex	Equation	SE	R	R^2
Male	H = 1.148a + 0.635b + 1.250c + 73.288	4.024	0.829	0.687
Female	H = 1.151a + 1.260b + 0.534c + 69.840	3.730	0.747	0.557

H- Height (cm); a- Tibial length (cm); b- Ulnar length (cm); c- Radial length (cm); SE- Standard error of the estimate (cm); R- Correlation coefficient.

Table 5: Comparison of different studies in males

Study	Tibia			Radius			Ulna		
	Length (cm)	R	SE (cm)	Length (cm)	R	SE (cm)	Length (cm)	R	SE (cm)
Present study	42.24±3.04	0.714	4.93	26.73±2.07	0.630	5.47	29.02±1.69	0.625	5.50
Celbis [4]	-	-	-	24.5±1.15	0.638	4.70	26.4±1.23	0.619	4.80
Mall [5]	-	-	-	24.6±1.25	-	7.73	26.5±1.54	-	7.50
Mohanty [9]	37.08±2.34	0.952	2.87	-	-	-	-	-	-
Bhavna [10]	36.48±1.91	0.765	3.67	-	-	-	-	-	-
Ozaslan [12]	38.37±2.40	0.740	4.46	-	-	-	-	-	-
Choi [13]	35.20±2.10	0.781	4.23	23.0±1.3	0.735	4.62	24.7±1.3	0.714	4.97

R- Correlation coefficient; SE- Standard error of the estimate (cm).

Table 6: Comparison of different studies in females

Study	Tibia			Radius			Ulna		
	Length (cm)	R	SE (cm)	Length (cm)	R	SE (cm)	Length (cm)	R	SE (cm)
Present study	39.43±0.30	0.661	4.12	24.33±0.17	0.560	4.55	27.64±0.19	0.605	4.37
Celbis [4]	-	-	-	21.7±1.19	0.852	3.50	23.6±1.20	0.764	4.30
Mall [5]	-	-	-	22.0±1.03	-	7.73	23.8±1.07	-	7.55
Mohanty [9]	35.03±2.60	0.939	3.44	-	-	-	-	-	-
Bhavna [10]	33.66±1.50	0.717	3.42	-	-	-	-	-	-
Ozaslan [12]	35.13±2.22	0.790	3.93	-	-	-	-	-	-

R- Correlation coefficient; SE- Standard error of the estimate (cm).

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