

ORIGINAL ARTICLE

# Stature Estimation from Forearm Length: An Anthropometric Study on Medical Students of South Indian Origin

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## ABSTRACT

### INTRODUCTION

With the increasing frequency of mass disasters, identification of mutilated remains becomes quite challenging. With commingling identification becomes further difficult. During such investigations there is a need to estimate the stature to narrow down the identity of the dead. Estimation of stature is more accurate and reliable using long bones than any other part of the body. Despite a need for such a study, there is lack of systematic studies to identify fragmented and dismembered human remains.

**AIM:** The aim of present study is to analyse anthropometric relationship between the forearm length and body height in both sexes specifically for population of South India.

**MATERIALS AND METHODS:** The study was conducted in the Department of Forensic Medicine & Toxicology, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Ramanagara District, Karnataka in the year 2022. The material consisted of 180 young and healthy students (90 males and 90 females) in the age group of 18-24 years after taking informed consent to participate in the study. Subjects of south Indian origin were selected based on their mother tongue. The data obtained were computed and analysed using Statistical Package for Social Sciences (SPSS, version 26.0) computer software.

**RESULTS:** In the present study, mean stature and forearm length were significantly higher in males than females. Statistically significant correlation was observed between stature and forearm length. Correlation coefficient was higher among males than females. Linear regression models derived for reconstruction of stature in males  $y = 2.5345 (\text{forearm length}) + 101.64$  and in females is  $y = 3.4513 (\text{forearm length}) + 73.879$ .

**CONCLUSION:** Study concludes that stature can be estimated from forearm length with a reasonable accuracy among South Indians. Sex specific linear regression formulae were derived for estimating stature from forearm length.

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KEYWORDS | FORENSIC SCIENCE; STATURE; FOREARM LENGTH; IDENTIFICATION; ANTHROPOMETRY.

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**INTRODUCTION**


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Identification of the dead and in certain circumstances of the living is of paramount importance in forensic practice. Primary characteristics of identification are age, sex and stature. With the increasing frequency of mass disasters, identification of mutilated remains becomes quite challenging. With commingling identification becomes further difficult. During such investigations there is a need to estimate the stature to narrow down the identity of the dead. Stature estimation from skeletal remains and body parts is based on the principle that height of an individual has a definite and linear relationship with various body parts and long bones of an individual.<sup>1</sup>

Estimation of stature is more accurate and reliable using long bones than any other part of the body. Despite a need for such a study, there is lack of systematic studies to identify fragmented and dismembered human remains. The present study was carried out to analyse anthropometric relationship between the forearm length and body height in both sexes specifically for population of South India.

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**OBJECTIVES OF THE STUDY**


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1. To find co-relation between Forearm Length & Stature of Individual (male & female).
2. To obtain regression formula to determine stature from forearm length.

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**MATERIAL AND METHODS**


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The study was conducted in the Department of Forensic Medicine & Toxicology, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Ramanagara District, Karnataka in the year 2022. The material consisted of 180 young and healthy students (90 males and 90 females) in the age group of 18-24 years after taking informed consent to participate in the study. Subjects of south Indian origin were selected based on their mother tongue.

Informed consent was taken from each of the participants. Approval was taken from Institutional Ethical Committee.

Measurements are taken at fixed time to avoid diurnal variations. The measurements were taken three times to avoid error. The subjects were measured for

- **Stature (S):** It is obtained as a distance between floor and the highest point on the head when subject is standing in standard standing position, using anthropometric rod.
- **Forearm length (FL):** It is measured from head of radius to tip of styloid process of radius using standard measuring tape.

**Inclusion criteria**

1. Medical Students who are healthy in the age group of 18-24 years with normal physical development studying in Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Ramanagara District, Karnataka.
2. Subjects of south Indian origin using mother tongue (Tamil, Telugu, Malayalam, and Kannada etc.) as a criteria for origin.

**Exclusion criteria**

Students with history of skeletal deformity, physical disability and those who are taking hormonal treatment.

**Statistical analysis**

The data obtained were computed and analysed using Statistical Package for Social Sciences (SPSS, version 26.0) computer software. Correlation coefficient was calculated and the correlation between the stature and forearm length was drawn. Regression formulae were derived for stature estimation from forearm length in males and females. P-value of less than 0.05 was considered as significant.

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**RESULTS**


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In males, stature ranged from 155.5 cm to 186.5 cm and forearm length ranged from 23 cm to 31 cm. (Table 1).

**Table 1:** Stature and Forearm length in males

Parameter	Minimum	Maximum	Mean	SD
Right Forearm length (cm)	23	31	26.93	2.01
Stature (cm)	155.5	186.5	169.91	6.89

In females, stature ranged from 141cm to 171 cm and forearm length ranged from 21 cm to 27.5 cm (Table No. 2).

**Table 2:** Stature and Forearm length in females

Parameter	Minimum	Maximum	Mean	SD
Right Forearm length (cm)	21	27.5	24.53	1.21
Stature (cm)	141	171	158.53	6.48

Mean stature was significantly larger in males (169.9 cm) than in females (158.5 cm). Mean forearm length in males was 26.93 cm and it was 24.53 cm in females.

**Table 4:** Linear regression equation and Standard Error of Estimate

Sex	Coefficient of determination (R <sup>2</sup> )	Linear regression equation stature y- stature, x – forearm length	Standard Error of Estimate (SEE)
Males	0.55	y = 2.53 x + 101.64	4.68
Females	0.41	y = 3.45 x + 73.88	5.00

The equation in males is y = 2.53 x + 101.64 and in females is y = 3.45 x + 73.88. Standard Error of Estimate was 4.68 in males and 5.00 in females.

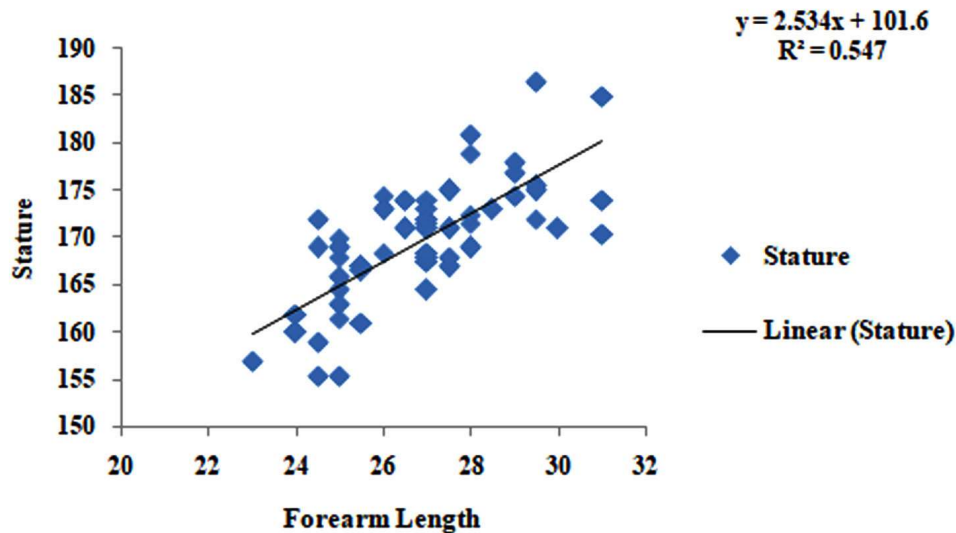
Descriptive statistics of stature and forearm lengths are shown in Chart No 1 and 2 and in Table No. 3 and 4. Statistically significant correlation was observed between stature and forearm lengths (Table 3).

**Table 3:** Correlation coefficient between stature and forearm length

Sex	Pearson Correlation coefficient (r)	Standard Error of Correlation coefficient
Males	0.74	0.0715
Females	0.64	0.0818

Pearson correlation (r) for stature and forearm length was higher among males (0.74) than females (0.64).

Linear regression models derived for reconstruction of stature in males and females are shown in Table No. 4.



**Chart 1:** Correlation between stature and forearm length among Males

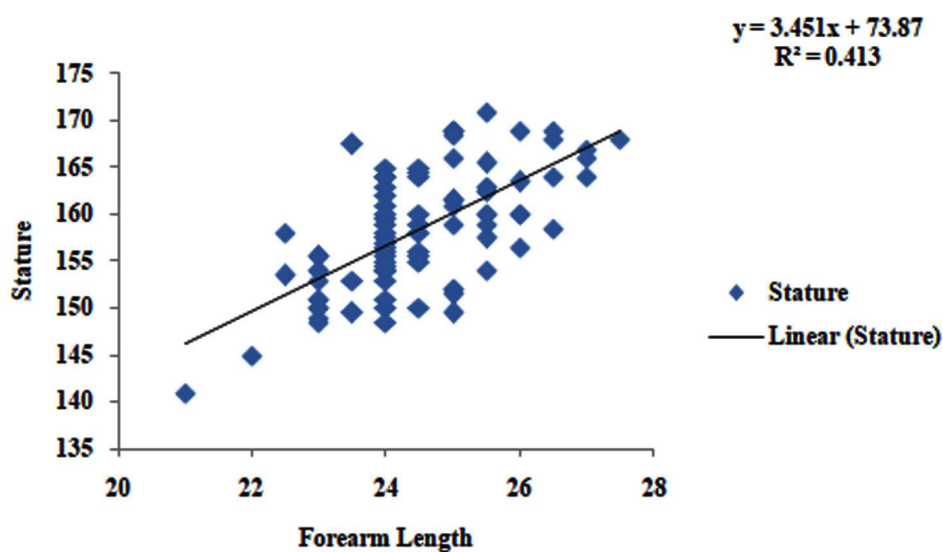


Chart 2: Correlation between stature and forearm length among Females

#### DISCUSSION

Dismembered remains and body parts are frequently encountered in rural India especially in forests and water bodies. Fulfilling the objectives of forensic autopsy is highly challenging in such cases. After determining sex and age of the remains, estimating stature is vital in identification. Proportion of lengths of different parts of the body to one another and to the stature varies considerably in different individuals. Skeletal growth and development in human beings are influenced by genetics and nutrition. Stature and length of long bones differ in Indians of different ethnicity. Regression equation derived for a particular population in India cannot be generalised and applied to all population of different ethnicity. Studies where stature can be estimated from forearm lengths in South Indian population are few. Hence the present study was conducted to correlate forearm length with stature in both sexes specifically for population of South India.

Amongst the study sample, mean stature was significantly larger in males (169.9 cm) than in females (158.5 cm). Mean forearm length in males was 26.93 cm and it was 24.53 cm in females. Statistically significant correlation was observed between stature and forearm lengths (Table 3). Pearson correlation ( $r$ ) for stature and forearm length was higher among males (0.74)

than females (0.64).

Uzun O et al. in their study observed highest correlation between stature and both forearm lengths after upper extremity length. ( $r=0.753$  for Right,  $r=0.734$  for Left).<sup>2</sup>

The results in a study on Thai children showed that the correlation coefficients between stature and forearm (ulna and radius) length are high and significant in both sexes ( $r = 0.988 - 0.992$ ,  $p < 0.01$ ). In Thai school age children, forearm lengths (radial length) highly correlated with stature (standard error of estimation range from  $\pm 2.7464$  cm to  $\pm 3.1190$  cm).<sup>3</sup> Standard error of estimation estimated in the present study is 4.68 and 5.00 for males and females respectively.

Linear regression models derived in the present study for reconstruction of stature in males and females are shown in Table 4. The equation in males is  $y = 2.5345x + 101.64$  and in females is  $y = 3.4513x + 73.879$ . In a similar study done on North Indian population, linear regression equation calculated was males:  $S = 126.28 + 1.815$  (Forearm length); females:  $S = 160.37 + 0.020$  (Forearm length)<sup>4</sup>

An anthropometric study was conducted by Ebrahimi B et al. on students of Hamadan University of Medical Sciences, Iran and they

found a strong positive correlation between forearm length and stature, and a moderate positive correlation between the stature and hand length. (Stature= $66.268+4.033\times$ forearm length, SEE= 0.230 and R<sup>2</sup>= 0.661) (Stature= $122.327+2.725\times$ hand length, SEE= 320 and R<sup>2</sup>= 0.314).<sup>5</sup>

Potdar AB et al. in their study on 200 medical students in Kolhapur found that there was a positive co-relation between forearm length and stature (r=0.83). Regression equation was derived to estimate stature from forearm length male subjects it was  $Y=2.66X+100.87$  and for females it was  $Y=3.28X+78.53$ . There was positive correlation between forearm length and stature in both male (r=0.69) and female (r=0.64).<sup>6</sup>

Panjakash S et al. established definite correlation between stature and forearm length in North Karnataka population and regression equation was formulated as; Stature of males in cm =  $2.887 \times$  RFL + 95.82. Stature of females in cm =  $2.632 \times$  LFL + 95.08.<sup>7</sup>

Balachandran M and Vasvani V in their study on Kerala subjects concluded that there was a moderate correlation between right forearm length and height and this correlation is statistically significant. They derived

regression equation for both males and females.

Height (Male) =  $90.24+2.19\times$  Right forearm length

Height (Female) =  $77.32+3.19\times$  Right forearm length<sup>8</sup>

Present study has come out with regression equations for South Indian population for both sexes.

Stature  $y = 2.53$  (forearm length) + 101.64 for Males.

$y = 3.45$  (forearm length) + 73.88 for Females.

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#### CONCLUSION

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The present study shows significant and positive correlation between stature and forearm lengths in males and females. Correlation coefficient was higher among males than females. Linear regression equations derived would help in estimation of stature from forearm length with a reasonable accuracy in South Indian Population.

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