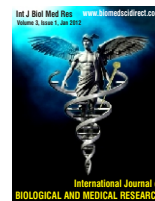


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### Original article

## Estimation of Height from Measurement of Foot Length in Gujarat Region

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#### ABSTRACT

**Aims:** Our aim of the study was to investigate the relationship between foot length and body height and to derive a regression formula in order to predict the height of an individual using foot length. **Methods:** The present study was conducted on total 505 asymptomatic, healthy students of Gujarat in the age group of 14 to 25 years. All the measurements were taken by using standard measuring devices and standard anthropometric techniques. **Results:** The obtained data was analysed for male, female and both the genders together. In both the sexes, foot length correlates significantly with the body height presenting correlation coefficient of 0.779 in total subjects, of 0.925 in all males and of 0.741 in all females. Further analysis was done by dividing the subjects into 14-19 years (adolescents) age and 20-25 years (Adults) age. In first age group, correlation coefficient between the two parameters was 0.803 in total subjects, 0.936 in males and 0.692 in females. In adult age group, correlation coefficient was 0.759 in total subjects, 0.910 in males and 0.804 in females. **Conclusion:** The results obtained after various statistical analysis shows that fairly good estimation of height can be made using regression equations in either sex.

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### 1.Introduction:

Height is determined by a combination of genetic and environmental factors. It is a sum of the length of certain bones and appendages of the body which is very useful anthropologically to find racial differences. Height estimation is of particular importance medico-legally, where the determination of height itself is a major step in identification of a subject when only parts of the deceased body are available.

Height estimation by measurement of various long bones and radiographic material has been attempted by several workers with variable degree of success. Each worker has derived his own formula for calculating the stature from long bones. However, foot measurement has not frequently been used for this. It was Rutishauser who for the first time showed that reliability of

prediction of height from foot length was as high as that from long bones [1].

Ossification and maturation in the foot occurs earlier than the long bones and therefore estimation of height from foot length could be different in adolescents and adults. Hence, an effort has been made to find out correlation between foot length and body height in adolescents and adults of Gujarati population.

### 2. Material and Methods:

For present study, total 505 (253 male and 252 female) asymptomatic, apparently healthy, adolescent and adult students belonging to various regions of Gujarat were selected. The age ranged between 14 to 25 years. A slow decline in the height is known to occur as the age advances and therefore older subjects were not studied. Subjects were further divided into adolescents (between 14 years to 19 years) and adults (between 20 years to 25 years) according to WHO guidelines [2].

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The left foot was selected for measurement as per recommendation of the international agreement for paired measurements at Geneva (1912). Foot length was measured as a direct distance from the most prominent posterior point of the heel to the tip of the hallux or to the tip of second toe (when the second toe was longer than hallux) by using the spreading caliper.

Height of the individual was measured in standing erect anatomical position with standing height measuring instrument. The measurements were taken at a fixed time between 2.00 to 4.30 p.m. to eliminate diurnal variation and by the same person to avoid personal error in methodology.

The obtained data was then statistically analysed by linear regression analysis.

### 3.Observations and results

The observation was done on 253 males and 252 females, total 505 Gujarati students. The linear regression analysis of the obtained data has provided the regression equations for estimation of height as shown in Table 1, 2 & 3. Graph 1, 2 & 3 show regression lines for all the subjects, adolescents and adults respectively. The graphs explain the linear relation between height and foot length. It can also be said that height can be predicted from foot length with fairly good accuracy as they show significant 'p' value.

**Table 1: Correlation coefficient and regression equation for height from foot length in total cases**

Subjects	Correlation coefficient (r)	Regression equation	P value
Total	0.779	Ht = 66.15 + (4.033) FL	<0.001
Male	0.925	Ht = 77.89 + (3.55) FL	<0.001
Female	0.741	Ht = 38.0 + (5.192) FL	<0.001

**Table 2: Correlation coefficient and regression equation for height from foot length in adolescence age group (14-19 years)**

Subjects	Correlation coefficient (r)	Regression equation	P value
Total	0.803	Ht = 65.96 + (4.005) FL	<0.001
Male	0.936	Ht = 77.03 + (3.582) FL	<0.001
Female	0.692	Ht = 51.35 + (4.590) FL	<0.001

**Table 3: Correlation coefficient and regression equation for height from foot length in adult age group (20-25)**

Subjects	Correlation coefficient (r)	Regression equation	P value
Total	0.759	Ht = 69.30 + (3.955) FL	<0.001
Male	0.910	Ht = 79.14 + (3.504) FL	<0.001
Female	0.804	Ht = 33.18 + (5.480) FL	<0.001

### 4.Discussion:

The estimation of height from various long bones, head length and hand length has been attempted by many workers. Since the development is influenced by a number of factors producing differences in skeletal proportions between different geographical areas, it is important to know such quantitative differences.

Table I, II & III show correlation coefficient between height and foot length in total subjects, adolescents and adults in either sex.

Many researchers have tried to predict height using various bones and body parts such as hand [3]. Singh and Sohal and Jit and Singh have shown a significant correlation between height and length of clavicle [4,5]. Athawale derived a regression equation between total height and forearm bones [6]. Patel, Joshi and Dongre have derived regression equation between tibia and total height in Gujarati population [7]. Shroff and Vare have also derived the height from length of superior extremity and its segments [8]. Saxena et al derived a regression equation between head length and height and find significant correlation coefficient [9].

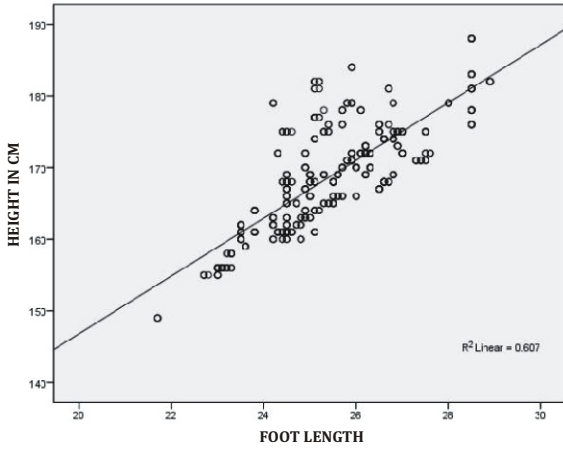
Regarding the estimation of height from foot length, Charnalia showed moderately significant correlation between height and foot length in Pondicherry population where correlation coefficient was 0.46 [10]. Qamra et al found a significant correlation between height and foot length (male 0.69 and female 0.70) in North West India population, whereas in our study the same was 0.925 and 0.741 which is again highly significant [11].

The regression equation for stature estimation was formulated using foot lengths and checked for their accuracy by comparing the estimated stature and the actual stature. The results indicate that foot length provides an accurate and reliable means in reconstructing the stature of an unknown individual. Furthermore, ossification of the bones of the foot occurs earlier than the other long bones of the lower extremity. Therefore, even during adolescent age, height can be predicted more accurately from foot measurements than from the other long bones of the lower limb. This is evident in our study where correlation coefficients in adolescents and adults do not differ much (Table 2,3).

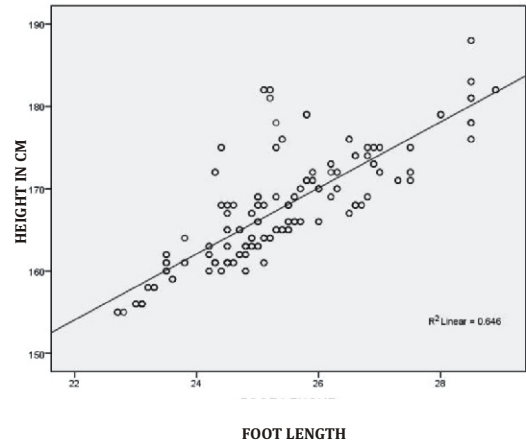
Estimation of an individual's stature is an important parameter in forensic examinations and anthropological studies. Examination of foot prints provides important evidence in a crime scene investigation which helps in the estimation of stature of a criminal. Otherwise estimation of stature also gives the investigator the opportunity to gauge that aspect of an individual's physical description which is useful in archeological studies as well.

**Graph 1 (A,B & C) : Correlation between height and foot length in total cases (1A), males (1B) and females (1C) of all age groups.**

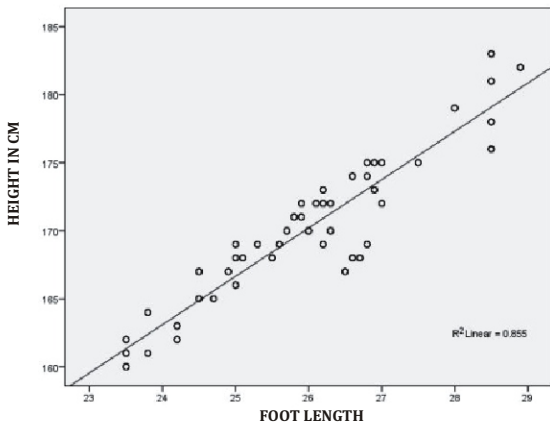
**Graph 2 (A, B & C): Correlation between height and foot length in total cases (2A), males (2B) and females (2C) of adolescence age group**



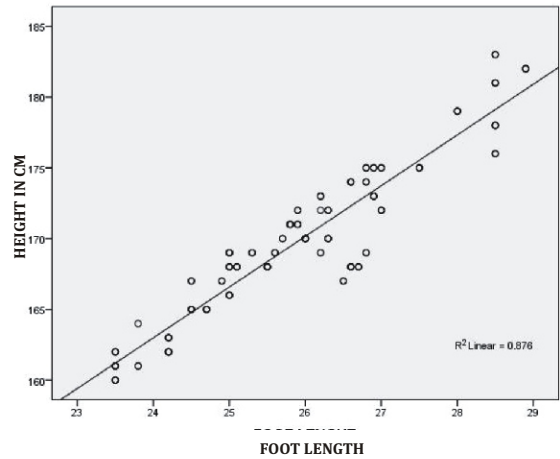
**Graph 1A**



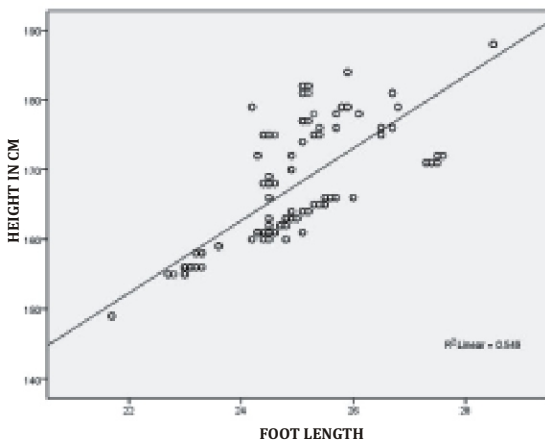
**Graph 2A**



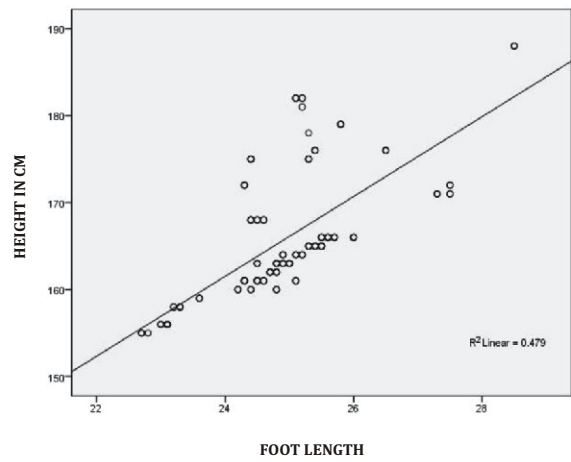
**Graph 1B**



**Graph 2B**

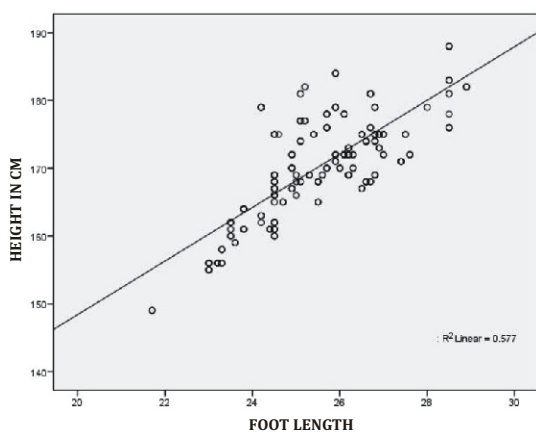


**Graph 1C**

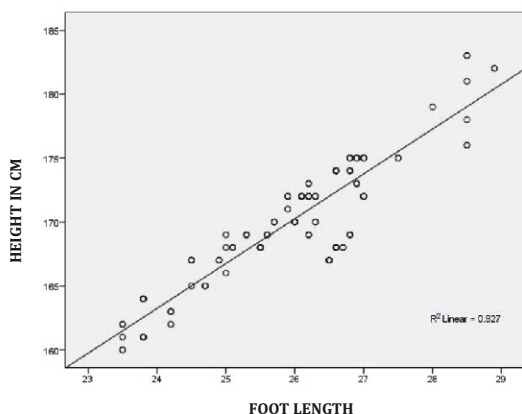


**Graph 2C**

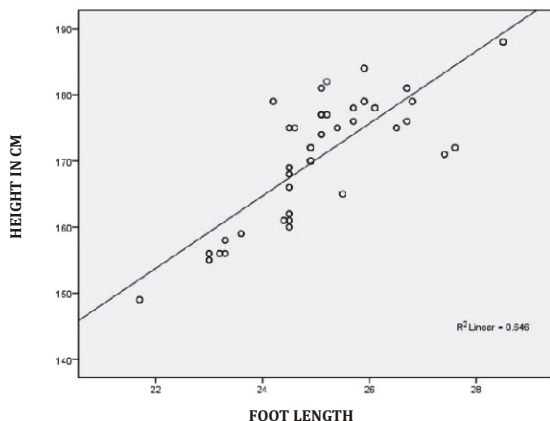
**Graph 3 (A, B & C): Correlation between height and foot length in total cases (3A), males (3B) and females (3C) of adult age group**



**Graph 3A**



**Graph 3B**



**Graph 3C**

development is influenced by a number of factors producing differences in skeletal proportions between different geographical areas, it is important to know such quantitative differences.

Table I, II & III show correlation coefficient between height and foot length in total subjects, adolescents and adults in either sex.

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