Original Article

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Estimation of stature from Foot length in Middle Gujarat Population

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Abstract

Estimation of height from measurement of various body parts is of particular interest to many anthropologists, anatomist and forensic scientist for its importance in medico-legal cases. Our aim was to investigate the relationship between personal stature and footlength & to derive a regression formula to predict the height of an individual using foot length. The present study was conducted on 200 apparently healthy students (100 males and 100 females)studying in various places of Middle Gujarat Region between 18 -25 years of ages. All these measurements were done by using standard anthropometric instruments and standard anthropometric techniques. Data was analysed separately for male and female. Estimation of stature using regression analysis using foot length gives the correlation coefficient for both sexes. It is concluded that linear regression analysis is goodfor estimating accurate stature.

Keywords: Stature; Foot Length; Regression Analysis; Correlation Coefficient.

Introduction

The determination of stature is amajor step in the identification of dismembered remains. Anthropometric techniques are commonlyused by anthropologist and adopted by medical scientist to estimate body size for the purpose ofidentification. Many studies have been carried out to estimate stature by taking measurements of long bones and radiographic materials [1].

Height is fundamental for assessinggrowth and nutrition, calculating body surfacearea, and predicting pulmonary function during childhood.

There are studies, in which anattempt has been made to establish the correlation between stature and foot length.This study extends the findings of previous studies by exploring datathat is height, and foot length, using linear regression models. These formulaeare applicable to that population from whichthe data has been taken.

Material & Method

Samples for the study consisted of consecutive asymptomatic, apparently healthy 200 (Males=100 and Females=100) students of Middle Gujarat regions. Their nutritional and socioeconomic statuses were not assessed. The age range was between 18-25 yrs. A slow decline in the height isknown to occur as the age advances andtherefore older subjects were not studied [2].

The subjects were studied for Stature and Foot length. All the measurements are taken using standard anthropometric instruments in centimetre to thenearest millimetre according to techniques describedby Vallois [2].

Height of the individual was measured in standingerect anatomical position with standing height measuring instrument. Foot lengthwas considered as the maximum lengthbetween the most prominent posterior point of theheel and the tip of hallux and the tip of the secondtoe if it is larger than the hallux.

The data was analysed using Microsoft excel methods used were regression analysis.

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Observation and Result

Table 1 indicates that

a. Mean height of the males to be 169.0 cm with a standard deviation of +/- 11.0 cm. Mean height of females has been found to be 158.0 cm with a standard deviation of +/- 8.0 cm.

b. Mean foot length of the males of the left side to be 23.5 cm with a standard deviation of +/- 1.2 cm whereas mean foot length of right side of males has been found to be 23.6 cm with standard deviation of +/- 1.3 cm. Mean foot length of female of left side has been found to be 21.1 cm with a standard deviation of +/- 1.0 cm whereas the mean foot length of right side was observed to be 21.2 cm with a standard deviation of +/- 1.0 cm.

Table 1: Measurement of Total Height and Length of Feet in Males and Females

Measurements	Male		Female	
	Mean value (cm)	Standard Deviation (+/- cm)	Mean value (cm)	Standard Deviation (+/- cm)
Total Height	169.0	11.0	158.0	8.0
Length of right foot	23.6	1.3	21.2	1.0
Length of left foot	23.5	1.2	21.1	1.0

Table 2: Correlation coefficients and regression equations for estimation of stature from length of foots

Subjects	Side	Correlation Coefficient (r)	Regression Equation
Male	Right foot	0.9331	7.0980x + 0.9890
	Left foot	0.9085	7.2086x -0.6922
Female	Right foot	0.8873	7.3808x + 0.2998
	Left foot	0.8977	7.3976x + 0.6446

Table 3: Shows comparison between correlation coefficient and regression equations as derived in studies of different ethnic groups in India

Studies done In different ethnic Groups	Correlation Coefficient (Male)	Correlation Coefficient (Female)	Regression Equation To measure stature in Males	Regression Equation to measure stature in Females
Khanpurkar S. et al.[3]	0.645	0.702	90.0+ 3.2FL	72.8 + 3.7 FL
Narde AL et al.[4]	NA	NA	6.2921+ / - 0.06 (R)	6.4497 + / - 0.13 (R)
			6.2786 + / - 0.07 (L)	6.4324 + / - 0.13 (L)
Chikhalkar B et al.[5]	0.6102	NA	79.7237 + 3.6506 FL	NA
Brenda MA Rohren[6]	0.840	NA	0.1647x - 3.024	NA
Dayananda R. et al.[7]	0.636	NA	69.346 + 3.663 FL	NA
Babu RS et al.[8]	0.583(R)	0.66 (R)	82.83 + 3.468 (R)	73.523 + 3.615 (R)
	0.585 (L)	0.653 (L)	80.955 + 3.547 (L)	79.83 + 3.349 (L)
Jakhar JK et al.[9]	0.527(R)	0.697 (R)	86.620 + 3.414 (R)	73.132 + 3.721 (R)
	0.525 (L)	0.719(L)	80.671 + 3.648 (L)	65.194 + 4.068 (L)
Rani M et al.[10]	0.808 (R)	0.808 (R)	98.320 + 3.050 (R)	90.207 + 3.374 (R)
	0.731 (L)	0.809 (L)	97.279 + 3.080 (L)	91.109 + 3.309 (L)
Khairulmazidah M et al.[11]	0.697 (R)	0.645 (R)	84.663 + 3.321 (R)	86.554 + 3.115 (R)
	0.659 (L)	0.662 (L)	92.819 + 2.972 (L)	84.325 + 3.214 (L)
Singh A. et al.[12]	0.497	0.213	1.4x+ 134.2	2.771x + 94.65
Present study	0.933(R)	0.887 (R)	7.098x + 0.989 (R)	7.381x + 0.299 (R)
	0.908 (L)	0.898 (L)	7.209x -0.692 (L)	7.398x + 0.645 (L)

Table 2 indicates that

a) In Males, correlation coefficient (r) of right foot is about 0.9331 and Regression Equation is 7.0980x + 0.9890 while of left foot, correlation coefficient (r) is 0.9085 and Regression Equation is 7.2086x -0.6922.

b) In Females, correlation coefficient (r) of right foot is about 0.8873 and Regression Equation is 7.3808x + 0.2998 while of left foot, correlation coefficient (r) is 0.8977 and Regression Equation is 7.3976x + 0.6446.

Discussion

All the human beings occupyingthis globe belong to the same species i.e. *Homosapiens*. No two

individuals are exactly alike inall their measurable traits, even genetically identical twins (monozygotic) differ in somerespects. These traits tend to undergo change invarying degrees from birth to death, in health and disease, and since skeletal development isinfluenced by a number of factors producing differences in skeletal proportions between different geographical areas, it is desirable tohave some means of giving quantitativeexpression to variations which such traits exhibit. Anthropometry constitutes that means, as it is thetechnique of expressing quantitatively the formof the human body. In other words, anthropometry means the measurement of human beings, whether living or dead or on skeletal material.

The Table 3 clearly shows variations regression equations in different ethnic groups of India.

Sanli SG et al. (2005) [13] stated that the multiple linear regression model isbest fitted than simple linear regression model for estimating height from foot and hand length. The R value was 0.928 while R2 value was0.861.

Krishnan K (2007) [1] concluded that the dimensions of hands and feet can provide good reliability in estimation of stature. It was observed that the multiple regression equations reveal lower values of Standard Error of Estimate (SEE) than the values given by linear regression equations. Interpretations suggest that the multiple regression equations are better indicators of stature estimation.

The results obtained inour study correlates with the study of Khanpurkar S. et al. (2012) [3].

The results of the study of Brenda MA Rohren [6] of 40 subjects indicated a higher positive correlation between footlength and stature than for shoe length and stature. He recommended that preference be given to foot lengthmeasurements in estimating stature whenever possible.

A study of Jakhar JK et al. [9] shown that foot length in males and females show highest correlation with stature and minimum standard error in estimation of stature. So the foot length provided the highest reliability and accuracy in estimating stature. The left foot length gives better prediction of stature than the right foot length.

In the study of Rani M et al. [10] both left and right foot measurements have been given due consideration and inboth males as well as females. Linear regression equations were derived for estimation of stature reliably and accurately that would be of immense value in the field ofcrime detection. Stature, foot length and foot breadth are positively and significantly correlated with each other ($p<0.01$). The higher correlation coefficient between stature and foot length over that of stature and foot breadth points to the fact that foot length, rather thanfoot breadth, is more accurate in estimating stature.

Singh A. et al. [12] concluded that both arm-spanand foot length can be used in estimation of theheight of both males and females. It was also found that estimating heightby using arm-span as well as foot length showed less deviation in females as compared to males.

Conclusion

It is concluded that males have greater mean value of stature as compared to that of females. It was also observed that there is direct relationship between foot lengths with the stature in both sexes. These regression equations and multiplication factors are specific for this region only because of geographical variations in the morphology of different population group. Estimation of statureusing simple linear regression equation by uses single parameter i.e., foot length is good but multiple linear regression analysis is better over simple linear regression analysis for estimating accurate stature.

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