



## Estimation of Height from Foot Length in 17-25 Years Age Group

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### Abstract

*For identification of the individuality of a person, variety of parameters have been followed, stature, being one of them. Estimation of stature from various measurements of the body is of value in medicolegal investigations as well as in anthropology. The proposed study dealt with developing a regression equation for stature estimation from foot length and also with finding out the correlation between stature and foot length. The study aimed at assessing the height of an individual, from measurements of foot length. It also dealt with developing a regression equation for stature estimation from foot length and finding out the correlation between stature and foot length. A cross sectional study was carried out in 165 medical students in which a regression equation of  $y=57.136+4.37x$  was established. Also the correlation between the height and foot length was observed to be highly significant with a value of 0.852.*

**Keywords:** Foot length, Height/ Stature, Regression equation.

### Introduction

Of the three primary characteristics of identification, age, sex and stature<sup>(1)</sup>, stature is one of the most important elements in the identification of an individual<sup>(2)</sup>. It is an important measure of physical identity that is defined as the height of the person in the upright posture<sup>(3)</sup> or more precisely the vertical distance between the highest point of vertex and the heel touching the floor.

Assessing the height of an individual, from measurements of different parts, has always been of immense interest to the anatomists, anthropologists and forensic medicine experts<sup>(4)</sup>. Examination of skeletal remains recovered from a scene of crime, have often been used by the forensic anthropologists

to extract relevant information about the victim. One such aspect pertains to reconstruction of living stature from such skeletal remains<sup>(5)</sup>.

Like other parts of the body such as head, trunk, lengths of upper and lower limb, the foot size also displays a definite biological correlation with stature. On the basis of this relationship, it is possible to predict the stature from the foot and its segments<sup>(6)</sup>. Personal identification from foot and its segments becomes more important in cases of mass disasters, where there is always likelihood of recovering feet (often enclosed) in shoes separated from the body.

Moreover, ossification and maturation in the foot occurs earlier than the long bones and therefore,

during adolescence age, height could be more accurately predicted from foot measurement as compared to that from long bones.

### Materials and Methods

165 students of age group 17 to 25 years were taken as the subjects for this study. Ethical clearance from IRC, KMCTH was obtained prior to starting the study. Informed consent of participants was taken and socio-demographic indices like age and sex were noted. Each student was studied for the measurements of stature and foot length.

Height of the individual was measured in standing erect anatomical position in centimeters through stadiometer.

Foot length was taken of the left foot, as per recommendation for paired measurements at Geneva. Foot length was measured as a direct distance from the most prominent point of the back of the heel to the tip of hallux or to the tip of second toe when the second toe was longer than hallux in centimeters through caliper. The subjects having any disease of foot, deformity, injury, fracture, amputation or record of any surgical procedures were not included in this study. Also the subjects who did not give consent were not included in the study.

### Results

The height of the subjects in this study was observed to be of range 144.1cm to 187.1 cm with mean of 163.42 cm. The standard deviation observed was 8.73. The mean height in the males was 169.39 cm with standard deviation of 6.22 and that of females was 156.748 cm with standard deviation of 5.87; the details of which are given in table 1. Similarly, the mean left foot length was observed to be 24.32 in both genders with a standard deviation of 1.7. The details of the left foot indices are shown in table 2.

**Table 1:** Height in both males and females

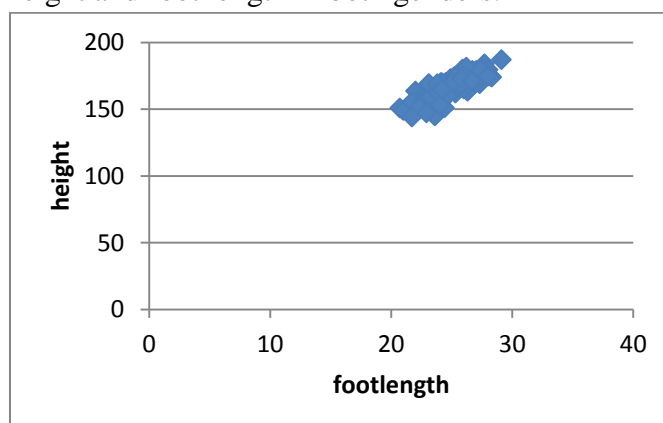
Parameters	Males	Females	Both genders
Total Number	87	78	165
Height Range (cms)	157-187.1	144.1-169.2	144.1-187.1
Mean Height	169.39	156.748	163.44
Standard Deviation of Height	6.22	5.874	8.729

**Table 2:** Left foot indices in both males and females

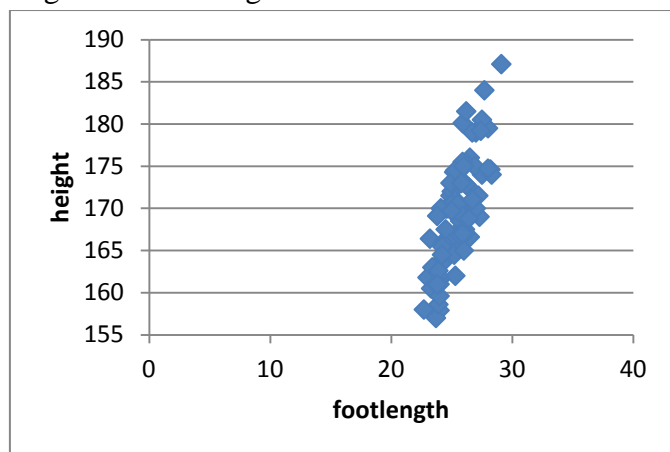
Parameters	Males	Females	Both genders
Left Foot Length Range	22.7-29.1	20.7-26.3	29.1-20.7
Mean Left Foot Length	25.46	22.76	24.32
Standard Deviation of Left Foot Length	1.377	2.79	1.7
Correlation Coefficient	0.765	0.607	0.852
Regression Coefficient (b)	3.46	3.55	4.37
Value of Constant (a)	81.38	74.85	57.14

The correlation coefficient of 0.852 in both genders was observed in our study as depicted in figure 1, which is highly significant. Figure 2 and 3 shows the correlation between height and the foot length of male and female respectively, which again are significant showing that there is a strong positive correlation between height and foot length of people. The regression equation was derived to be  $y=57.136+4.37x$ , where y is the height and x is the foot length measured.

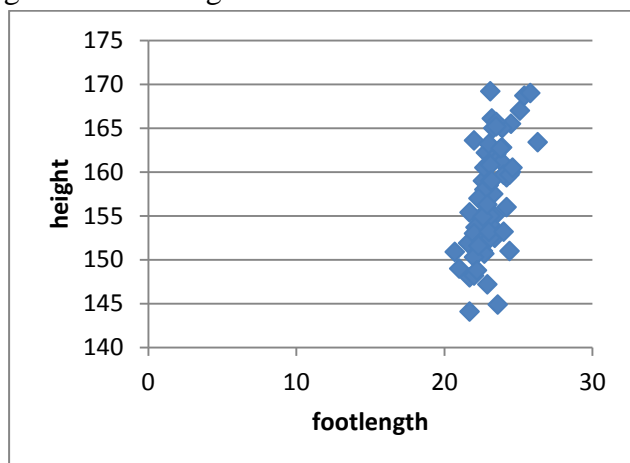
**Figure 1:** Scatterplot showing correlation between height and foot length in both genders:



**Figure 2:** Scatter plot showing correlation between height and foot length in male:



**Figure 3:** Scatterplot showing correlation between height and foot length in Female



### Discussion

In this study, a cross sectional study was performed in 165 medical students of age group 17-25 years, studying in the Kathmandu Medical College and Teaching Hospital, Duwakot. Height and foot length of the subjects were measured in order to see their correlation and establish a regression equation. Estimation of the stature from the bones has been done following various methods, however, regression analysis has been considered as the easiest and most reliable method.

In this study, left foot measurement has been taken as per the recommendation of the International agreement for paired measurements, though some studies <sup>(7),(8),(9),(10)</sup> have not shown any statistically significant interside difference. Robbins in her study concluded that

either of the foot could be used for estimation of height<sup>(11)</sup>. Agnihotri et al correlated foot length and stature in Mauritians (125 males and 125 females). They also derived regression equations to calculate height. However, they used right foot for analysis<sup>(12)</sup>.

In this study, the height of the subjects ranged from 144.1cm to 187.1 cm with mean of 163.42 cm. The male height ranged from 157-187.1 (mean 169.39) and that of females ranged from 144.1-152.5 (mean 156.748).

Standard deviation of the height in males was observed to be 6.22 and in females 5.874 with a standard deviation of 8.729 as observed in both the genders.

In the second table, observations for the left foot range is shown as in male 22.7-29.1 (mean 25.46) and in female 29.1-20.7 (mean 22.76 )and in both genders 29.1-20.7 (mean 24.32).

The mean range of the left foot in both genders in our study coincides with the study done by Vineet Dhaneria et al<sup>(4)</sup>. The correlation coefficients between parameters as height and foot length shown in the table are positive, suggesting that it is significant. The correlation coefficients between height and foot length, indicate the foot length provides highest reliability and accuracy in estimating stature of an unknown individual. A study conducted by Rameswarapu Suman babu et al<sup>(13)</sup> in Secunderabad, India shows a correlation coefficient of 0.8 in both genders which is similar to our study (0.852).

Estimation of the height by measurement of various long bones has been attempted by several workers with derivation of their own formula for calculating the stature from long bones. However, foot measurement has not frequently been used for this. Rutishauser was the first one to show that reliability of prediction of height from foot length was as high as that from long bones<sup>(14)</sup>. Since then, a couple of research works have been carried out in estimating the stature by foot length.

A study done by Kewal Krishnan et.al<sup>(15)</sup> by estimation of stature from foot print and foot outline dimensions in Gujarat of North India suggests that the correlation of stature with foot length is extremely high suggesting a close relationship with them.

Jitendra kumar Jakhar<sup>(16)</sup> had also carried out study in department of forensic medicine and toxicology at Haryana state. A total number of 103 medical students were included which showed good correlation of height was observed with foot length and it was statistically highly significant.

In Nepal, similar study has been conducted by Mansur DI et al<sup>(3)</sup>, in which highly significant correlation coefficient of 0.688 in male and 0.587 in female, between height and foot length was observed. Likewise, correlation coefficient of 0.765 and 0.607 in males and females respectively and 0.852 in both genders were observed in our study, which is highly significant.

### Conclusion

A definite correlation between stature and foot-length and regression equations has been established in our study. The measurement of either height or foot length, if known, the other can be calculated which can be of great help in medico legal cases in establishing identity of an individual in cases where only some remains of the body are found as in mass disasters, bomb explosions, accidents etc. though more studies should be conducted among people of different regions & ethnicity as a lot of variations are observed in estimating their height from limb measurements so that more reliable and accurate stature estimation becomes can be done.

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