Estimation of Stature from Foot Length in Adult Nepalese Population and its Clinical Relevance

Mansur DI,[1] Haque MK,[1] Sharma K,[1] Karki RK,[2] Khanal K,[3] Karna R[4]

[1]Department of Anatomy

[2]Department of Forensic Medicine

[3]Department of Community Medicine

[4]Tutor, KUSMS

Corresponding Author

Dil Islam Mansur

Department of Anatomy

Kathmandu University School of Medical Sciences

Dhulikhel, Nepal

Email: drdilislam@gmail.com

ABSTRACT

Background

Stature is the height of the person in the upright posture. It is an important measure of physical identity. Interrelationships among different body measurements may be used to estimate one from another in case of missing body parts.

Objective

Stature is an important indicator for identification. There are numerous means to establish stature and their significance lies in the simplicity of measurement, applicability and accuracy in prediction. The current study dealt with developing a regression equation for stature estimation from foot length and to find out the correlation between body height and foot length of Nepalese people.

Methods

The present study was carried out to establish the regression equation and correlation coefficient between individual's height and mean foot length. It was conducted on 440 students of age group 17 to 25 years studying in Kathmandu University School of Medical Sciences, Dhulikhel, Nepal. Body height and foot length were measured in centimeter.

Results

There was significant correlation between height and foot length (r = 0. 703, p < 0.01).The regression equation for height and foot length was found to be Y = 3.179 X + 87.65, where X is the foot length and Y the height.

Conclusions

This study will help in medico-legal cases in establishing identity of an individual and this would be useful for Anatomists and Anthropologists to calculate stature of adult Nepalese based on foot length.

KEY WORDS

Age, body height, correlation coefficient, foot length, regression equation and its coefficient.

INTRODUCTION

Stature is the height of the person in the upright posture. It is an important measure of physical identity. Establishing the identity of an individual from mutilated, decomposed and amputed body fragments has become an important necessity in recent times due to natural disasters like earthquakes, tsunamis, cyclones, floods and man-made disasters like terror attacks, bomb blasts, mass accidents, wars, plane crashes etc. It is important both for legal and humanitarian reasons. "Stature" is one of the most important elements in the identification of an individual.[1]

Dimensional relationships between the body segments and the whole body have been of interest to artists, scientists, anatomists, anthropologists and medicolegistics for long time.[2] 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.[3]

In medico-legal autopsies, establishing personal identity of the victims is often required. Estimation of stature from extremities and their parts plays an important role in identifying the dead body in forensic examinations.[4]

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. The aim of the present study was to find out the correlation between foot length and height of an individual and to derive regression formulae to estimate the height from the foot length in the Nepalese population.

METHODS

The present study was conducted at School of Medical Sciences, Kathmandu University, Dhulikhel, Nepal under Department of Anatomy. Sample size was taken as 440 (258 male and 182 female) asymptomatic, healthy medical students of the age group ranging between 17 – 25 years. The subject having any disease or deformity was not included in this study.

Foot length was measured as a direct distance from the most prominent point of the back 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 spreading caliper in centimeter.

Height of the individual was measured in standing erect anatomical position with standing height measuring instrument in centimeter.

RESULTS

There is significant correlation coefficient between height and right foot length(r = 0.688, p < 0.01 for male and r = 0.587, p< 0.01 for female), height and left foot length (r = 0.689, p < 0.01 for male and r = 0.589, p < 0.01 for female) and height of entire subjects and mean foot length (r = 0.703, p < 0.01) . It means that there is strong positive correlation between height and foot length of people. The regression equation for height and foot length was found to be y= 2.738x+ 100.2 (for left foot of male), y = 2.74x + 100.1 (for right foot of male), y = 2.66x + 96.40 (for left foot of female), y = 2.66x + 96.31 (for right foot of female), Y = 3.179 X + 87.65(for both male and female and mean foot length), where X is the foot lenght and Y is the height.

Table I. Age V/s Height and Foot Length.

Age	Mean height in cm		Mean foot length in cm	
	Male	Female	Male	Female
17	165.000	-	23.0000	-
18	166.7435	155.0000	23.4382	22.5762
19	165.0070	156.7804	23.7831	22.3679
20	164.4848	159.1458	23.5905	22.8906
21	168.7035	156.7692	24.1800	22.6923
22	166.0403	155.2812	24.5383	22.6562
23	165.6629	154.1111	24.2857	22.8556
24	166.1250	150.2500	25.2500	22.8333
25	163.7500	-	24.2500	-

Table 2. Height, foot length, correlation coefficient, regression coefficient (b) and value of constant (a) in Male and Female.

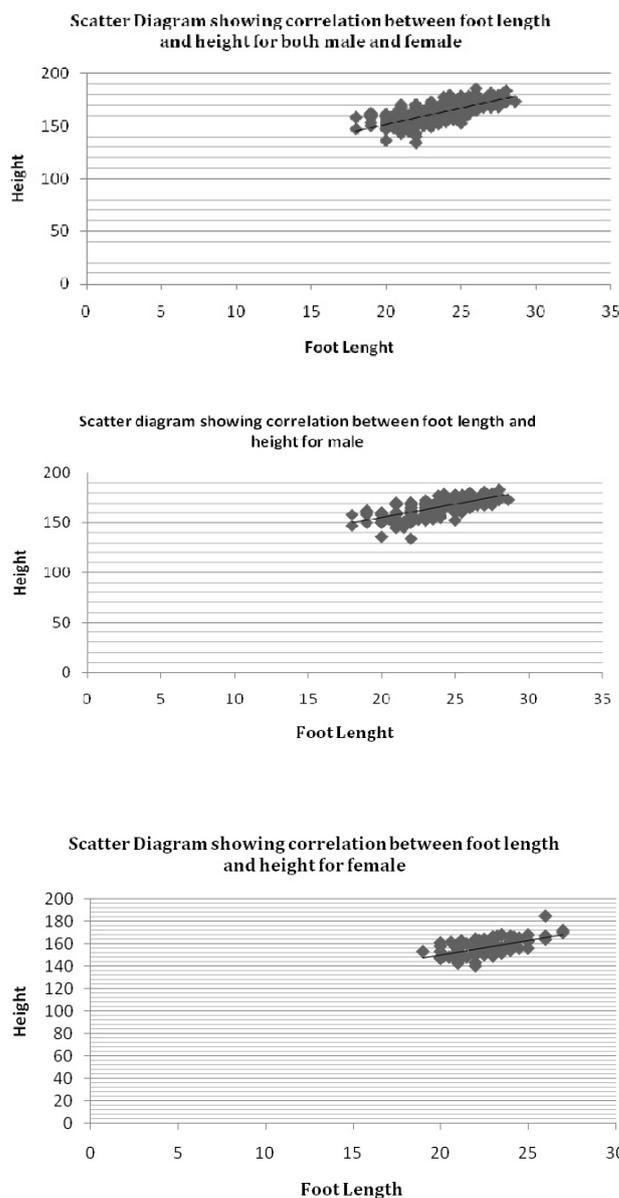|	Male	Feamale
Total Number	258	182
Height range (cm)	134 - 183	140 – 185
Mean height (cm)	165.66	156.70
S.D. of height	8.34	6.16
Foot length Range (cm)	18 - 28.5	19 -27
Mean foot length (cm)	23.89	22.64
S.D. of foot length	2.09	1.36
Correlation Coefficient(r) (Height and Foot Length)	0.688	0.587
Regression Coefficient (b)	2.73	2.66
Value of Constant (a)	100.18	96.40

Figure 1. Correlation between foot length and height

DISCUSSION

Various studies have been conducted on the estimation of stature from the human skeleton. There are various methods to estimate stature from the bones but the easiest and the reliable method is by regression analysis. In the present study we have observed the correlation of height (in anatomical position) with foot length amongst Kathmandu University School of Medical Sciences students. Medical students were chosen for the easy availability of the subjects. Table-I shows that the age ranges from 17 to 25 years, foot length from 18- 28.5 cm in male and 19 to 27 cm in female and total height from 134 to 183 cm in male and 140 to 185 cm in female with a significant correlation between them.

Table 2 shows the correlation coefficients between various parameters. Between age and height, between age and foot length and between height and foot length. It is 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.[4]

Height estimation by measurement of various long bones has been attempted by several workers with variable degree of success. Each researcher 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.[5]

Natarajamoorthy T et.al studied on 107 randomly selected subjects in Malaysia and developed a regression equation for stature estimation from foot length obtained from foot impression.[6] Groote ID et.al studied on the skeletal sample compromised 87 individuals (Andamanese, Australians, Africans, Native Americans and British) and found a regression equation using first metatarsal bone to estimate stature.[7] Shushil Kumar et.al measured length of forearm and hand of 200 male medical students age ranging 18-25 years in India and developed a formula.[2] Akhter Z et.al examined head circumference and length of 100 Garo female subjects were included from Dhaka city and Mymensingh district, Bangladesh and advised head circumference showed significant positive correlation with stature but head length did not reach statistically significant level with stature.[8] Bhavna et.al have been studied on 503 male Shiah Muslim of Delhi, India and reported a body dimension which correlates highly with stature.[3] Ebite LE, et.al in their study on 109 healthy adults (45 male and 66 female) at Urome, Edo state, Nigeria and derived a formula based on Ulna length.[9] Dayal MR et al studied on 169 people (98 white male and 71 white female) and derived a regression formula for the estimation of total skeletal height and thereafter to predict stature in South African whites using long bone length.[10] Patel SM et.al in their study on 502 medical students (278 male and 224 female) between 17 to

22 years of age belonging to various region of Gujarat, India and reported a regression formula between foot length and height of an individual.[5] Krishna K, et al. have been studied on 252 Koli male adolescents from North India and suggested that all the cephalo-facial measurements are significantly correlated with stature.[11] Krishna K, et.al reported a regression equation for stature estimation from dimension of hand and feet in a North Indian Population.[4] Jadav HR, et al. took length of head of 727 (468 male and 259 female) medical students belongs to various region of Gujarat, India and established a regression equation.[12] Mall G, et al in their study on 143 individuals (64 male and 79 female) reported correlation between the bone lengths of forearm and the stature led to unsatisfactory results with large 95% confidence intervals for the coefficients and high standard errors of estimate.[13] Saxena SK, et.al who derived a regression equation between head-length and height in Agra population. Their correlation coefficient between head-length and height was +0.2048.[14] Qamra S, et al made a study on height and foot length and derived a correlation coefficient for foot breadth (Male 0.42 and Female .0.47) and foot length (Male 0.69 and Female 0.70).[15] Shroff AG, et al. have also derived the height from the length of superior extremity and its segments.[16] Patel MP, et al. have derived regression equation between tibia and total height in Gujarati population.[17] Athawale MC derived a regression equation between total height and forearm bones.[18] Charnalia VM showed the significant correlation between height and foot-length, where correlation coefficient was 0.46.[19] According to John G, nasion-inion length (head-length) is 1/8 of the total height of an individual.[20] Singh B, et al.and Jit I, et al. have shown a significant correlation between height and length of clavicle.[21,22]

No such type of study was carried out in Nepal. In present study the correlation coefficient between height and foot length is + 0.688 in male and + 0.587 in female which is highly significant. From the above facts, it is clear that if either of the measurement (foot length or total height) is known the other can be calculated and this fact may be of practical use in Medico-legal investigations and in Anthropometry.

CONCLUSION

The present study has established definite correlation between stature and foot-length and also regression equations have been established. It will help in medico-legal cases in establishing identity of an individual when only some remains of the body are found as in mass disasters, bomb explosions, accidents etc. If either of the measurement (foot length or total height) is known, the other can be calculated and this would be useful for Anthropologists and Forensic Medicine experts. It will also help in establishing identity in certain civil cases

There are lot of variations in estimating stature from limb measurements among people of different region

& race. Hence there is a need to conduct more studies among people of different regions & ethnicity so that stature estimation becomes more reliable & identity of an individual is easily established.

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