ESTIMATION OF STATURE FROM FOOT LENGTH MEASUREMENTS IN STUDENTS OF A MEDICAL COLLEGE OF KATHMANDU: A CROSS-SECTIONAL STUDY

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ABSTRACT

Identification refers to the determination of individuality of a person based on certain physical characteristics. It has been proved by researchers that a strong co-relation exists between one's stature and footprint/ foot outline measurements. Estimation of stature forms a basic domain during the investigation of unknown/ comingled human remains. The dimensions measured in the lower extremities of the body have greater association with the stature of the individual than those from the upper extremities. This study was conducted from May 2024 to October 2024 AD in 153 medical students of Nepal Medical College, Kathmandu. The height of each person of the study was measured using height scale and right and left foot length was measured using vernier calipers. Linear regression formula (a+bx) for estimating the stature of male and females and of total subjects, was obtained from the data entered in SPSS version 16. Based on the data, the mean height of males was 170.41 ± 6.12, that of females was 158.28 ± 6.21. The right and left foot length of males was 24.41 ± 1.24 and 24.64 ± 1.26 and for females was 22.36 ± 1.17 and 22.39 ± 1.19 respectively. Significant associationwas obtained between the height and foot lengths of males and females of the study.Regression formulae were obtained from the respective heights and foot lengths of total sample, males and females which showed significant co-relation (P <0.0005). Based on the results obtained from the data, it is evident that there is significant co-relation between stature and foot length and foot length measurement. This study has limitations regarding small study population and intra-observer bias.

KEYWORDS

Identification, stature, mass disasters, foot outline measurements, regression formula

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INTRODUCTION

Identification refers to the determination of individuality of a person based on certain physical characteristics such as name, age, sex, religion, race, anthropometry (stature), fingerprints, footprints, DNA typing, congenital or acquired malformations etc.[1] Identification of persons from footprint measurement is an emerging biometric technique. Foot outline is defined as the line tracing the outer margins of the fleshed foot and also represents the boundaries of the foot's impression in soft soil, mud, or other soft surfaces that produce a three-dimensional footprint impression. It has been proved by researchers that a strong co-relation exists between one's stature and footprint/ foot outline measurements.[2]

Forensic podiatry deals with the application of sound and researched podiatric knowledge and experience in forensic investigations which may arise in cases of mass disasters, mass murders, transport accidents, tsunamis, floods and earthquakes. Stature is a measure of physical identity and refers to the height of a person in the upright posture. Estimation of stature forms a basic domain during the investigation of unknown / comingled human remains.[3]

In unidentified human remains, establishing the personal identity is the most important criterion based on physical anthropology. In cases of mass disasters/homicides, the recovery of an entire body may not be possible and the foot may be recovered as they may be protected inside shoes and they may withstand heat and other climatic factors more effectively. Allometry refers to the estimation of stature from body parts. Estimation of stature from foot can be done by reasonable accuracy. Foot length is the most frequent parameter used in the estimation of stature from foot.[4]

Significant and positive co-relation coefficient has been shown to exist between stature and measurement of foot prints.[5] Height could be more accurately estimated from foot measurement as compared to measurements of long bones as ossification and maturation occurs in the foot earlier than long bones.[6]

It is possible for establishing feet dimensions and stature of a person. The estimation of height of a person is a major step in the recognition of mutilated remains.[7] Estimation of stature is important both for legal and humanitarian reasons. Height could be more accurately predicted from foot as ossification and maturation in foot occurs earlier than long bones.[8]

The core element of forensic investigations is identification of an individual. The relationships of stature to the length of bones differ among populations such as inter-racial and inter-geographical differences.[9] The regression formula for stature estimation by foot length should be specific for sex and population according to several studies, due to interplay of genetic and environmental factors.[10] Ruthishauser showed for the first time that the reliability of prediction of height from foot length was as high as that from long bones as ossification and maturation in foot occurs earlier than in the long bones.[11]

The measurement of foot length is simple and accurate as compared to those of the long bones.[12] The dimensions measured in the lower extremities of the body have greater association with the stature of the individual than those from the upper extremities.[13] The determination of stature from incomplete skeletal and decomposing human remains is helpful in personal identification.[14] The measurements from foot have been utilized for prediction of stature and gender and their relationships have been established in various studies.[15]

MATERIALS AND METHODS

After getting ethical approval letter (Reference No. 67-080/081) from the Institutional Review Committee of Nepal Medical College, Attarkhel, the study was started from May 2024 till the end of October 2024. This was a cross-sectional study in which a total of 153 medical students of 18-25 years of age, who had been already been enrolled before the research and had been studying in first to final semester of the college during that time, were taken as participants for the study after getting their consent. Newly enrolled students, after the study started, were excluded. Also, students with abnormality of foot, other spinal deformities and age group other than 18-25 years were excluded. The instruments used in this study were height scale and vernier calipers. All the measurements were taken by a single individual (the researcher).

The following techniques were used while taking measurements and the data wasanalyzed using SPSS-16 and presented in relevant tables and figures.

Stature: Each participant was asked to stand up in a height scale in an erect posture against the wall with hands hanging down, with head in horizontal plane, without wearing any footwear. The stature was measured from the

vertex of the head to the heel. The mean height of the male and female subjects was calculated after measuring the height of the participants.

Foot length: The participant was asked to stand up on the floor, without wearing any footwear, so that both the feet would be slightly apart of each other. The right and left foot length of each individual was taken as the distance between the most posterior part of the heel and the most anterior part of the longest toe/ great toe on each side. The vernier caliper was placed horizontally andthe right and left foot length of the participant were taken as the distance between the heel and the longest toe/ great toe on each side. The foot length of right and left foot were measured separately in male and female participants. The mean foot length of right and left foot of the male and female subjects were calculated after using linear regression formula for estimating the stature.

Linear regression formula (y = a + bx) for estimating the stature of male and female subjects of the study was applied for the total subjects as well as separately (i.e. for male and female), where y is the stature, b is co-relation coefficient, x is the foot length and a is constant. This regression formula was used to fit linear equation to the observed data.

RESULTS

The mean height, mean right and left foot length of total subjects was 165.76 ± 8.47, 23.60 ± 1.55 and 23.76 ± 1.63. The mean height, mean right and left foot length of males and females was 170.41 ± 6.12, 24.41 ± 1.24 and 24.64 ± 1.26 and 158.28 ± 6.21, 22.36 ± 1.17 and 22.39 ± 1.19 respectively. A difference of near about 12 cm was observed in between the mean height of males and females. Similarly, a difference of more than 2 cm was observed in between males and females regarding the mean right and left foot length.

Table 1: Anthropometric measurement data mean for total subjects

Anthropometric measurement (Mean ± SD) in cm	Male	Female	Total
Height	170.41 ± 6.12	158.28 ± 6.21	165.76 ± 8.47
Right foot length	24.41 ± 1.24	22.36 ± 1.17	23.60 ± 1.55
Left foot length	24.64 ± 1.26	22.39 ± 1.19	23.76 ± 1.63

Table 2: Significance between height and foot length

Height and Foot length	P-value
Height and RFL of total subjects	0.01
Height and LFL of total subjects	0.01
Height and RFL of males	0.01
Height and LFL of males	0.01
Height and RFL of females	0.01
Height and LFL of females	0.01

Table 2 shows significant co-relation (p-value level of 0.01) between height and foot lengths of the total subjects as well as that of males and females.

Table 3 demonstrates the linear regression formulae for height and right and left foot length of total subjects in the form of y = a + bx, where y is height, a is a constant, b is independent variable coefficient and x is foot

Table 3: Stature estimation from regression analysis of right and left foot length for total subjects

Foot Length (cm)	Formula(y=a+bx)	P-value	Standard error	95 % Confidence interval	R^2
Right	y = 57.24 + 4.59x	<0.0005	0.24	4.12 - 5.06	0.70
Left	y = 60.80 + 4.41x	< 0.0005	0.22	3.97 - 4.86	0.72

Table 4: Stature estimation from regression analysis of right and left foot length for male subjects

Foot Length (cm)	Formula (y=a+bx)	P-value	Standard error	95 % Confidence interval	R^2
Right	89.71 + 3.30x	< 0.0005	0.39	2.53 - 4.08	0.44
Left	89.68 + 3.27x	< 0.0005	0.38	2.52 - 4.03	0.45

Table 5: Stature estimation from regression analysis of right and left foot length for female subjects

Foot Length (cm)	Formula (y=a+bx)	P-value	Standard error	95 % Confidence interval	R^2
Right	74.99 + 3.72 x	< 0.0005	0.50	2.70 – 4.73	0.50
Left	76.37 + 3.65 x	< 0.0005	0.49	2.66 – 4.63	0.50

length. It shows significant co-relation (p-value < 0.0005) in between the height and foot length. In addition, the table shows the standard error, confidence interval and R^2 of the sample.

Table 4 shows the linear regression formulae for height and foot length of male subjects of the study with significant co-relation (P <0.0005). Similar to table 3, it also shows the standard error, confidence interval and R^2 of the sample.

Table 5 shows the linear regression formulae for height and foot length of male subjects of the study with significant co-relation (P <0.0005). Similar to table 3 and 4, it also shows the standard error, confidence interval and R^2 of the sample.

DISCUSSION

This is a cross-sectional study was conducted to establish a relation between part of the body and the whole body in terms of stature by taking data of height and foot lengths and applying regression formulae for them. Based on the results obtained from the data, it is evident that there is significant co-relation between stature and foot length and foot length measurement is an important parameter in the estimation of stature.

In this study, a difference of near about 12 cm was observed in between the mean height of males and females. Similarly, a difference of more than 2 cm was observed in between males and females regarding the mean right and left foot length. A significant co-relation (P of 0.01) was observed between height and foot lengths of the total subjects as well as that of males and females. Similarly, a significant co-relation (P <0.0005) was observed in between the height and foot length of total subjects as well as height and foot length of male and female subjects.

The results of this study were similar to a study conducted by Krishan *et al*[3] in 149 young females between the age of 13 and 18 years from Northern India which showed positive co-relation between stature and foot measurements and statistical significance with P < 0.001.

Similar study conducted by Moorthy *et al.*[2] in 200 Malaysian Chinese population showed high positive co-relation between height and footprint and foot outline lengths. It also showed increased co-relation coefficients (R) in the pooled sampled footprint and foot outline as compared to that of individual footprint and foot outline.

A Nepalese study, similar to this study, conducted by Mansoor *et al*[8] in 440 students of age group 17 to 25 years, studying in Kathmandu University School of Medical Sciences, Dhulikhel, Nepal also showed significant co-relation between height and foot length (R = 0.703, P <0.01).

The present study concludes that there is a strong statistical significance between stature and foot lengths of the subjects under study. It means that we can rely on the use of statistical tools such as linear regression for anthropometric measurement significance in later studies as well as use it for application in the real scenario such as mass disasters. In contrast to the valuable outcome of the study, it has limitations regarding small study population and intra-observer and inter-observer bias.

Conflict of interest: None

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