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AN ANTHROPOMETRIC STUDY ON ESTIMATION OF STATURE FROM PERCUTANEOUS LENGTH OF TIBIA IN UNDERGRADUATE MEDICAL STUDENTS

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ABSTRACT

Background
Stature add value in establishing identity of an individual. Mathematical equations are often used for deriving stature wherever identification is not feasible using anatomical methods. This study aimed at developing a regression equation to predict stature from percutaneous length of tibia.

Methods
In this cross-sectional study 167 undergraduate medical students of Devdaha Medical College and Research Institute were included among which 80 were males and 87 were females. Study was conducted from 15th May 2024 to 24th August 2024 after ethical approval was obtained. Stature was measured using stadiometer and percutaneous length of right tibia was measured from superior most end of the medial condyle to inferior most margin of the medial malleolus.

Results
The participant in this study falls under the age groups ranging from 18 to 26 years with a mean age of 20.68(±1.53) years. The mean length of the tibia was 39.11(±3.95) cm and mean height of the participants was 159.8(±7.6) cm. Regression analysis of this study demonstrated that tibia length is a significant predictor of stature in both males and females and, the predictive model was more precise in males. In combined equation where sexes were combined the model fit improved greatly with variance 65.2% confirming that predictive accuracy increases when the combined regression formula is applied.

Conclusion
Forensic anthropologist can use regression equation of various body parts for prediction of stature among which predictability from lower limb tends to be more accurate.

Keywords: *Forensic anthropology, Identification, Stature, Tibia*

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INTRODUCTION

Stature is one of the most important biological profiles which is often used in identification of the individuals[1]. Wherever only tentative identification is possible stature can add value to determine the profile[2]. Mathematical method of stature estimation uses regression equations derived from the skeletal elements of living subjects[2]. Mathematical equations are often used for deriving stature wherever identification is not feasible using anatomical method[3]. There are four demographic characteristics that are considered as pillars of identification and stature is one of them[2,4]. In cases where mutilated body parts are found such equations can play a vital role in identification by estimating stature and very few research had been done in this aspect[5]. In addition, due to uniqueness in the environmental, racial and genetic characteristics each population should have their own formula for the stature estimation[3]. This study was designed to fulfil these research gaps.

Studies had been done in past to develop formulas for stature estimation from various body parts in Nepal[6-9]. Studies in different regions of the world have been done to develop population specific regression formula for estimation of stature using length of tibia[4,10-14]. For a precise estimation of stature bones of the lower limb are suitable as they are the greatest contributor of height of individuall[5] and among them tibia is percutaneous throughout and its length and also contributes to 22% of the individuals' height[16].

Due to improved socio-economic status, nutrition level stature of new generations is in a increasing trend thus, changing relationship between height and length of bones as well.[17]. This study aimed to develop a regression equation based on the percutaneous length of the tibia of the Nepalese adult individuals that would help anthropologist, forensic scientists and anatomist to estimate the stature that would be valuable in defining the biological profile of the individual in this region.

METHODS

In this cross-sectional study 167 undergraduate medical students of Devdaha Medical College and Research Institute were included among which 80 were males and 87 were females. Nonprobability sampling method was used for sampling purpose. Ethical approval was taken from the Institutional Review Committee of Devdaha Medical College with the protocol ID: 04/2024 (Ref No. 984/080/081) Written informed consent was taken from students before collection of data which was done from 15th May 2024 to 24th August 2024.

Measurements

Data was collected between 10 A.M to 12 noon. Stadiometer was used to measure the stature of the participants, from vertex to heel. Participants were asked to stand erect with barefoot in anatomical position and head was positioned in Frankfurt's plane during measurement. For the measurement of percutaneous length of tibia, the participants were asked to sit on a chair with knee joint in 90º flexion. Foot was rotated laterally so that bony projections would be prominent. Two points were fixed, one on the superior most end of the medial condyle and another on the inferior most margin of the medial malleolus of the tibia and measurements were taken between the two points.[11]. This was considered as the length of the tibia. Measurement was exclusively taken of right side only. All the measurements were taken by a single investigator three times, and an average was calculated and noted in a proforma and was later entered in the excel spreadsheet.

Statistical Analysis

Statistical Analysis was done using IBM SPSS version 26. Descriptive statistics was calculated for height and length of tibia of right side that included mean, standard deviation, maximum and minimum. Kolmogorov Smirnov's test was done to assess the normality of data. Student paired t-test was done to compare the length of tibia between males and females. Linear regression equations were developed for estimation of height from the percutaneous length of the tibia and their R, R^2 and SEE were calculated. CI was set at 95% while level of significance was set at $p < 0.05$.

RESULTS

There were 167 participants in this study with age groups ranging from 18 to 26 years with a mean age of 20.68(±1.53) years. Mean length of tibia was 39.11(±3.95) cm with 22.34cm minimum and 46.93cm maximum and mean height of the participants was 159.8(±7.6) cm with minimum height of 141cm and maximum height of 174cm.

Table 1 shows the descriptive statistics of males and females. Mean tibial length in females was found to be 36.52(±3.47) cm and mean height 159.7(±7.6) cm whereas, mean tibial length in males was found to be 41.48(±2.67) cm and mean height was 172.8(±5.4).

Table 1: Descriptive statistics of the tibial length and height in male and female

Sex	Parameters	N	Minimum	Maximum	Mean	Std. Deviation
Female	Tibia Length(cm)	80	22.34	43.99	36.5222	3.47223
	Height(cm)	80	141	174	159.75	7.603
Male	Tibia Length(cm)	87	35.34	46.93	41.4833	2.67061
	Height(cm)	87	162	186	172.80	5.389

Kolmogorov Smirnov's test was done to assess the normality of the data, and it was found that tibial length was normally distributed (p= 0.066) and height of the participants was not distributed normally (p = 0.036). Thus Mann- Whitney U test was done to see the relation of height between males and females, and independent sample t-test was done to see the relation between the tibial length of males and females.

In an independent samples t-test it was observed that male students had significantly longer tibia lengths than female students $t(165) = 10.40$, $p < 0.001$, with a mean difference of 4.96 cm (95% CI: 4.02–5.90).

A Mann-Whitney U test was done to determine differences in height between males and females. Median height was significantly higher for males (Median = 172.1 cm) than for females (Median = 161.6), $U = 478.50$, $z = -9.62$, $p < .001$.

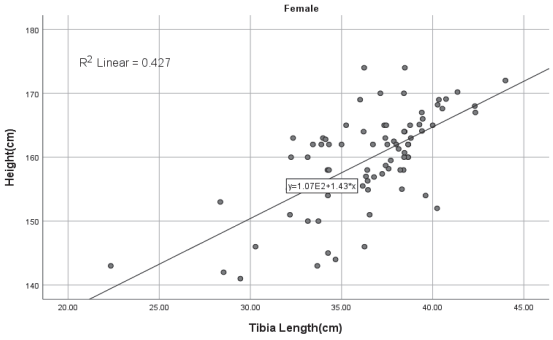

Figure 1: Scatter plot showing relation between height and tibia length in female

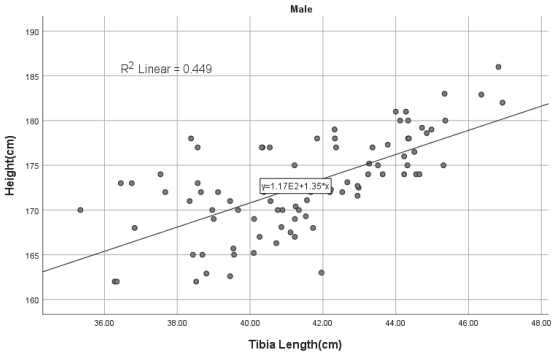

Figure 2: Scatter plot showing relation between height and tibia length in male

The regression equation for estimation of stature from tibial length for females is as follows:

Constant (b_0): 107.479
Coefficient for Tibia Length (b_1): 1.431
The regression equation is:
$y = 107.479 + 1.431(x)$, where y is the estimated stature and x is the length of tibia.

Regression equation for prediction of height from tibial length in males is as follows:
Constant (b_0): 116.702
Coefficient for Tibia Length (b_1): 1.352
The regression equation is:
$y = 116.702 + 1.352(x)$, where y is the estimated stature and x is the length of tibia.

Regression equation for prediction of height for tibial length in males and females combined is as follows:
Constant (b_0): 92.733
Coefficient for Tibia Length (b_1): 1.888
Therefore, the derived regression equation is:
$y = 92.733 + 1.888(x)$, where y is the estimated stature and x is the length of tibia.

Table 2 shows the model summary of the regression equations. It was observed that the equation was statistically significant for female, male and combined models with $p < 0.001$ for each equation. Thus, tibia length can be considered as a strong predictor of the height. The combined model explains the most total variance (65%) and SEE of 5.5cm while analyses by sex show a stronger relation and precise prediction in male model ($R^2 = .45$, SEE = 4.02 cm) than for females ($R^2 = .43$, SEE = 5.79 cm).

Table2: Model summary for the regression equations

Sex	Model	R	R^2	Adjusted R^2	SEE	*p* - value
Female	1	.654	.427	.420	5.791	0.000
Male	1	.670	.449	.443	4.023	0.000
Combined	1	.807	.652	.650	5.468	0.000

SEE = Standard Error of Estimates

DISCUSSION

In cases of mass destructions where dismembered body parts are present estimation of stature plays a vital role in identification of the individual [18]. Prediction of stature from the parameters of the lower limbs is more precise when compared with the upper limbs and a single parameter can work as an accurate predictor [18]. In this study we used percutaneous length of tibia to develop a regression equation that can estimate stature of Nepalese adults. The mean percutaneous length of tibia was found to be 36.52 cm for females and 41.48 cm for males in this study similar to few previous studies [1,14,19]. It is slightly higher than reported by Sah et al. 37.37 cm for males

and 34.9 cm for females[11], but much less than where they reported mean length of 40.50 cm for females and 47.10 cm for males taken in Romanian adults[4]. Environment, genetics and nutritional status might have affected the length of tibia in these cases. In an interesting study done to find stature using fragments of tibia it was found that regression equations can predict stature reliably using tibial fragments when full tibia is not available but when full length tibia is available it is stronger predictor of height[20].

In an independent sample t- test it was found that male students had significantly longer tibia when compared to females with $p < 0.001$. Similarly, Mann Whitney U test done for comparison of height also showed taller stature in males ($U = 478.50$, $z = -9.62$, $p < .001$). Significant differences have also been found in dimension of hand of males and females [6], and foot length of males and females[8]. Male being genetically taller than female is the reason for the variation. In a study done by Duyar et al. participants were divided into 3 groups named as short, medium and tall according to their height and found that tibia length increases positively according to height. Regression equations were developed for each group and they reported that group specific formulas should be used when estimation of stature is to be done using tibial length and individual's general build up should also be considered for accuracy [21]. No such groups were divided in this study.

There are body region specific regression equations developed in studies done in past[6-8, 22, 23]. Regression analysis of this study demonstrated that tibia length is a significant predictor of stature in both males and females. In female tibia length accounted for 42.7% variance in height ($R = .654$, $R^2 = .427$, $SEE = 5.79$, $p < .001$) and in males a variance of 44.9% was observed ($R = .670$, $R^2 = .449$, $SEE = 4.02$, $p < .001$). Thus, the predictive model was more precise in males. In combined equation where sexes were combined the model fit improved greatly with variance 65.2% ($R = .807$, $R^2 = .652$, $SEE = 5.47$, $p < .001$). So, it's confirmed that predictive accuracy increases when the combined regression formula is applied. Compared to this, in another study the predictability was more accurate in females with variance of 56.8% where males had a variance of 47.1%. But the combined equation had similar variance (61.6%) with significantly improved predictability [1]. Similarly in another study the variance was 40.2% for males and much higher, 67% in females [14]. Another study reported much higher variance in both males (74%) and females (72%) [12].

In this study participants of almost same age groups were included so that, although the equation can be applied for this specific age group it may not be accurate for other age groups. Sample size was also limited. Length of only right tibia was taken and comparison between the right and left tibia could not be done. Thus, in future studies can be done taking these limitations into account with a larger sample size, participants from various age groups and taking length of both right and left tibia. Other parameters that may improve predictability like the foot length could also be added to develop regression equation including multiple parameters.

CONCLUSION

Forensic anthropologists often use stature for identification of the individuals. It can be done using regression equation of various body parts among which predictability of lower limb tends to be more accurate. This study generated regression equations to estimate stature for males, females and combined both sexes using percutaneous length of tibia. It was observed that the regression equation derived from combined both sexes was more accurate. In future similar studies can be done taking multiple parameters and larger sample. This study would also be useful for anatomists and anthropologists.

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