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Original Article

Estimation of Stature from the Percutaneous Lengths of the Radial and Ulnar Bones in Gujarati Population

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ABSTRACT

Anthropometric characteristics have a direct relationship with sex, shape and form of an individual, and these factors are closely linked with each other in estimating the height of an individual from the available data, which forms the basis of forensic anthropology. The objective of this study was to formulate a regression equation to estimate the height of an individual by using percutaneous measurement of the radial and ulnar bone lengths in the Gujarati population. A cross-sectional survey was conducted at a teaching hospital in Vadodara, Gujarat, India. A total of 110 Gujarati students aged above 20 years were enrolled for the study. The standing height and percutaneous length of the radial and ulnar bones of both the sides were measured and recorded. Stature estimation can be done successfully for both males and females by using the different regression equations obtained in this study, of which the left radius is specific for males and the left ulna for females. This study will be of great help for the forensic experts, the anthropologists and the anatomists in solving various medico-legal issues.

Keywords: Anthropometry, Stature, Radius, Ulna, Gujarati population

INTRODUCTION

Estimation of the height from the bones is one of the important and useful anthropometric parameter that determines the physical identity of an individual.[1] It has been stated that various factors, such as race, sex and nutrition, play an important role in determining the height of an individual, and there is a definite relationship between the height of the person and the various parts of the body, like head, trunk and lengths of upper and lower limbs.[2] Estimation of the height of an individual from the amputated limbs has a great significance in personal identification in the events of murders, accidents or mass disasters, and it is of great help to an anthropological researcher and the forensic experts in solving many medico-legal issues. Estimation of the height from various long bones of the extremities is affected by factors like age, sex and race.[3] Intact long limb bones have been used in the derivation of regression equations for stature assessment in different population groups.[4]

The Trotter and Gleser[5] formulae are used most frequently in many parts of the world for stature estimation from long bone lengths. Krogman and Iscan[6] opined that the regression formula for stature estimation should be population specific. A comparative study was done using 15 different regression formulae obtained from different parts of the world to estimate the height using the ulnar bone length, and based on the results of the study, a new formula to estimate the height using the ulnar bone length for the Turkish population was formulated by Izzet *et al*.[7]

Ulna is a long bone at the medial side of the forearm, parallel with the radius. In ulna, the proximal epiphysis fuses with the shaft in the 14th year in females and in the 16th year in males. The distal epiphysis fuses with the

shaft in the 17th year in females and in the 18th year in males.

Radius is a long bone at the lateral side of the forearm, parallel with the ulna. In radius, the proximal epiphysis fuses with the shaft in the 14th year in females and in the 17th year in males. The distal epiphysis fuses with the shaft in the 17th year in females and in the 19th year in males.[8]

Many studies were conducted in the past throughout the world to estimate the height of an individual using the forearm bone lengths, but importance was given to the ulnar bone alone. Articles regarding the estimation of height using radial bone length are very limited. So, the aim of this study was to calculate the height of an individual using percutaneous measurement of the radial and the ulnar bone lengths on both the right and the left sides. In addition, we also aimed to check whether, with these measurements, a regression equation could be formulated to measure the height of an individual in the Gujarati population and discuss which among the four bones was specific for either of the sexes in estimating the height.

MATERIAL AND METHODS

In total, 110 subjects enrolled to this study, of whom 70 were male and 40 female students from a teaching hospital in Vadodara, Gujarat. They were from different parts of Gujarat. In this study, individuals aged more than 20 years were included and individuals with deformity or history of fractures of the upper limb were excluded. After explaining about the nature of the study to the students, an informed written consent was obtained prior to taking measurements.

To measure the height, an anthropometer was used. The height of the individual was measured from crown to heel, when the person was standing erect in anatomical position with the bare foot against a wall. The feet were kept parallel to each other, with heels, buttocks and back touching the wall. The head was kept in the eye-ear plane and then the height was measured to the nearest 0.1 cm.

To measure the length of the ulna, a sliding caliper was used. The subject was asked to sit, and the forearm was rested comfortably on a table with the palm facing downwards (full pronation) and the fingers extended but together. The elbow was flexed in the range from 90 to 110^0. The distance between the most proximal point of the olecranon and the tip of the styloid process of the ulna was measured.

To measure the length of the radius, a sliding caliper was used. The subject was asked to sit and the forearm was rested comfortably on the table, with palm facing sideward (mid pronation) and the fingers extended but together. The elbow was flexed in the range from 90 to 110^0. The distance between the most proximal point of the radius head and the tip of the styloid process of the radius was measured.

After recording different measurements from the subjects, data were entered in MS Excel 2007 and then analysed using statistical package SPSS version 16 for windows. Independent linear regression formulae to calculate the height were obtained from the radial and ulnar bone lengths for both males and females.

RESULTS AND OBSERVATION

Linear regression analysis was done by using the forearm bone lengths as independent variables and the height as a dependant variable as shown in Table 1 and 2.

DISCUSSION

Although many methodologies were used to estimate the

Table 1: Results obtained for male subjects

Forearm bones	Regression equation (Height =)	Percentage explained (r^2)	*P*-value
Right radius	123.039+1.811x(RRL)	0.282	0.000
Left radius	114.079+2.155x(LRL)	0.309	0.000
Right ulna	122.730+1.802x(RUL)	0.257	0.000
Left ulna	130.122+1.506x(LUL)	0.185	0.000

RRL, right radial length; LRL, left radial length; RUL, right ulnar length; LUL, left ulnar length.

Table 2: Results obtained for female subjects

Forearm bones	Regression equation (Height =)	Percentage explained (r^2)	*P*-value
Right radius	126.224+1.319x(RRL)	0.162	0.010
Left radius	125.355+1.360x(LRL)	0.151	0.013
Right ulna	133.370+1.012x(RUL)	0.125	0.025
Left ulna	127.854+1.240x(LUL)	0.179	0.007

RRL, right radial length; LRL, left radial length; RUL, right ulnar length; LUL, left ulnar length.

height from long bones, regression analysis proved to be the easiest and a reliable method (Medows *et al.*)[9]. Measuring the height using the ulnar bone length is superior to hand length (Ilayaperuma *et al.*),[10] tibial length (Joshi *et al.*)[11] and the arm span measurement (Gauld *et al.*).[12] The ulnar length has shown to be a reliable and precise means in predicting the stature of an individual (Ebite *et al.*).[13]

Regression formula to estimate the height from the radial and ulnar bone lengths is of much use in European, African, Mangolian and American populations and not reliable for the Asians, and this stated the importance of formulating different regression formulae to be followed for different races (Trotter and Gleser).[5] Madden *et al.*[14] conducted a comparative study of estimating the height from the ulnar bone length in order to show racial variation.

The present study shows that, in case of male subjects, all the four values were statistically significant (*P* value <0.001) and with high degree of correlation. Therefore, we can use either the radial or the ulnar bone length to calculate the height of an individual. The best among them was the left radius, which had the highest r^2 value.

In case of female subjects, all the four values showed a high degree of correlation and were statistically significant (*P* value <0.05). Therefore, we can use either the radial or the ulnar bone length to calculate the height of an individual. The best among them was the left ulna, which had the highest r^2 value.

Studies to estimate the height of an individual using the forearm bone lengths were carried out by Athawala[15] in the Maharastrian males, Balakrishnan *et al.*[16] in the Gujarati population and Illayaperuma *et al.*[17] in the Sri Lankan population. All the above-mentioned studies confirmed that the stature estimation could be done by using forearm bone lengths, wherein the forearm bone length considered was that of the ulna and not the radial bone. Our study results also confirmed that the ulnar bone length provided an accurate means in stature prediction similar to the previous studies.

In our study, along with the ulna, we used the percutaneous radial bone length in estimating the height of an individual and the results also suggest that it is possible to form a separate regression equation to estimate the height from the radial bone length in the Gujarati population. However, articles regarding the estimation of height using the radial bone length are minimal throughout the world.

CONCLUSION

The results show that there is a strong positive correlation between the stature and the forearm bones, namely, the radius and the ulna, on both the right and the left side in the Gujarati males and females. From this study, we came to know that estimation of height using the left radius was specific for males and the left ulna for females in the Gujarati population. The study also showed that this method was reliable, accurate and measured on an easily accessible part of the body. It provides valuable data to estimate the stature when only an amputated forearm is found. This will be of great use for the forensic experts, the anthropologists and the anatomists in solving many medico-legal issues like identification of individuals in cases of accidents, homicides, suicides and mass disasters.

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