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Estimation of personal height from the length of ulna bone

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Abstract
Many factors like, racial, gender, ethnic and nutritional factors play an important role in determining the height of an individual. Estimation of stature from measurements of various long bones has been achieved with varying degree of accuracy. Those studies resulted in establishing formulae for the estimation of height from long bones for the respective populations. However, literature shows that there is a great void in such norms for Sri Lankans. This study was carried out to investigate the relationship between personal height and ulna length among a group of male and female Sri Lankan adults and to derive a regression formula between the ulna length and height of an individual. A total of 258 adults with an age span of 20-23 years were included in the study. The ulna length was measured using a sliding caliper capable of measuring to the nearest 0.01 mm. The height of the individual was measured standing erect, in anatomical position using a standing height measuring instrument. The differences of the ulna length between the genders were found to be highly significant. A positive correlation between height and ulna length was observed in both sexes and it was statistically significant. Regression equations for height estimation were formulated using the ulna lengths for both sexes. The results indicate that ulna length provides an accurate and reliable means in estimating the height of an unknown individual. The regression formulae derived in this study will be useful for anatomists, archeologists, anthropologists and forensic scientists.

Keywords: Height, Ulna, Sri Lankan

Introduction

It is known that trunks and limbs exhibit consistent ratios among themselves and relative to total body height (Williams *et al.*, 2000). The ratios are age, sex and race dependent (Williams *et al.*, 2000). Establishment of various methods for personal height estimation is important in instances where height estimates needed to be made from fragments of bones in archeological procedures or in forensic examinations after disasters or genocide.

Various long bones have been employed for stature estimation (Athawale, 1963; Joshi et al., 1964; Shroff and Vare, 1979; Telkka, 1950). There is concern regarding the accuracy of the use of population specific formulae on other human population (Trotter and Glesser, 1952). Furthermore evidence show differences in the limb proportions between sexes and among populations (Meadows, 1996; Meadows and Jantz, 1999). For instance, Negros have comparatively long upper and lower limbs and consequently formulae designed to estimate height from that population may not apply to other population such as Asians (Ebite *et al.*, 2008).

The ulna is a long bone on the medial side of the forearm. Proximally the ulna has a bony process called the olecranon process which articulates with the humerus. Distally the ulna bears a styloid process. The olecranon is subcutaneous and easily palpable. Its position depends on the angle of flexion-extension of the elbow joint. In extension the tip lies in line with the epicondyles of the humerus and in full flexion three bony points make an equilateral triangle. The whole length of the subcutaneous border of the ulna is palpable down to the styloid process (Williams *et al.*, 2000; Sinnathamby, 1999).

Ossification of the ulna begins at the 8th week of fetal life. The proximal epiphysis fuses with the shaft in 16th year and the distal epiphysis unites with the shaft in 20th year (Williams *et al.*, 2000).

This study was designed to investigate the relationship between ulna length and height in a group of male and female Sri Lankan adults and to derive a

regression formula between the ulna length and height of an individual.

Materials and Methods

This study was conducted on 258 medical students (140 male and 118 female) of the Faculty of Medicine, University of Ruhuna, Galle, Sri Lanka. The subjects were from different parts of the island belonging to different socio-economic status. The age of the subjects ranged from 20-23 years.

Ulna length was defined as the direct distance between the tip of olecranon process to the styloid process with the elbow in full flexion. Ulna lengths were taken independently on left and right side of each individual using a sliding caliper capable of measuring to the nearest 0.01 mm (Mitutoyo, Japan).

The height of the individual was measured standing erect, in anatomical position with bare feet, using a standing height measuring instrument.

All the measurements were taken at a fixed time between 14.00 – 16.30 hrs. to eliminate discrepancies due to diurnal variation. Furthermore the measurements were recorded by the same person to minimize the errors in methodology. Each measurement was taken thrice and the mean was taken for further analysis. Results were expressed as mean ± SD and analyzed using a statistical package SPSS (15th version).

Results

Ulna lengths were taken independently on left and right side of each individual. Statistical analysis indicates that bilateral variation was insignificant for the measurements of ulna length in both sexes. Various important parameters of the study are summarized in Table 1.

Sex differences in height and ulna length were found to be highly significant ($P<0.0001$). Mean ulna lengths of the male were significantly larger than that of the females for all ages ($P<0.0001$). Bar charts relating ulna length and mean heights of male (Fig. 1) and females (Fig. 2) and scatter plots showing ulna length and total height of male and females are shown in Fig. 3 and Fig. 4 respectively.

Table 1. Height, ulna length, correlation coefficient, regression coefficient and value of constant in males and females.

Gender	Male	Female
Total number	140	118
Height range (cm)	[illegible]	144-168.7
Mean height (cm)	[illegible]	157.55 ± 5.75
Ulna length range (cm)	24.50-31.00	22.00-27.50
Mean ulna length (cm)	27.56 ± 1.30*	25.11 ± 1.24
Correlation Coefficient	0.66	0.76
Regression Coefficient	2.645	3.536
Value of Constant	97.252	68.777

* $P<0.0001$ when compared with the females.

Regression equation for stature estimation was derived as follows:

For male: Height = 97.252 + 2.645 (ulna length)

For females: Height = 68.777 + 3.536 (ulna length)

For both male and female (combined): Height = 57.385 + 4.047(ulna length)

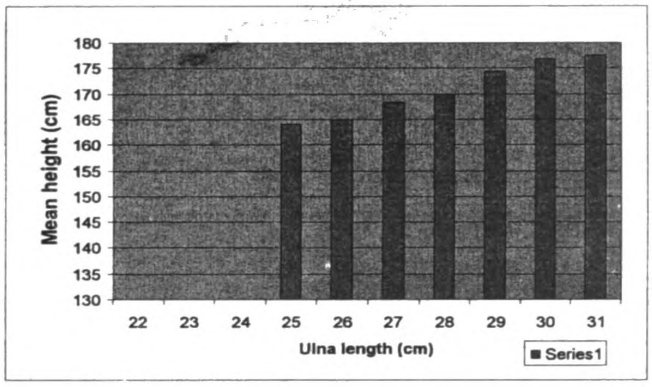

Figure 1. Bar chart relating ulna length and mean height of males

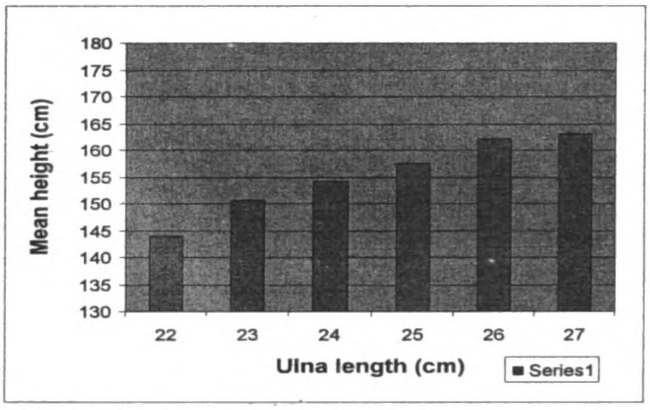

Figure 2. Bar chart relating ulna length and mean height of females

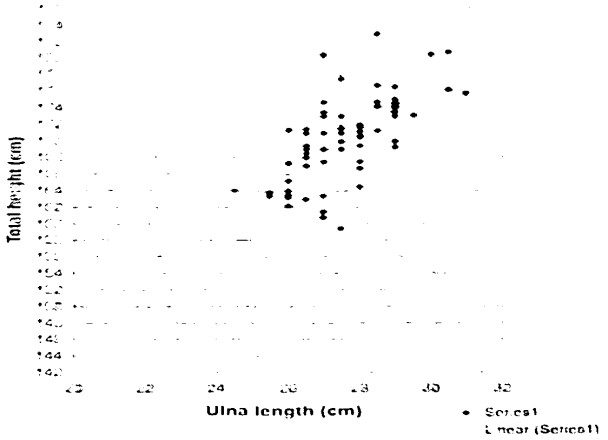

Figure 3. Scatter plot relating ulna length and total height of males

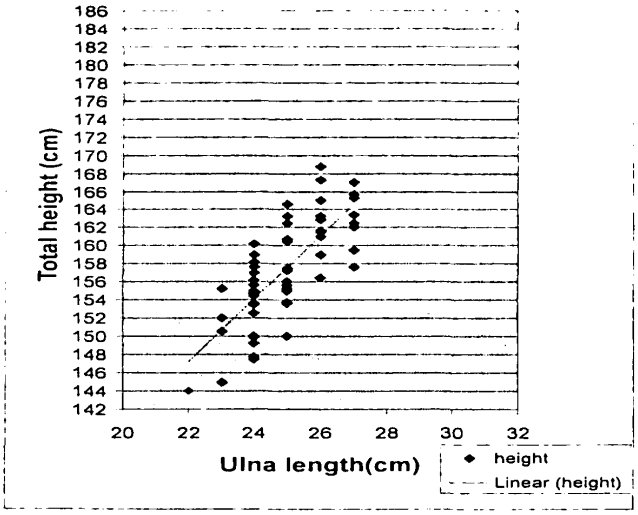

Figure 4. Scatter plot relating ulna length and total height of females

Discussion

The average height of adult males within a population is significantly higher than that of adult females (Williams *et al.*, 2000; Ilayperuma *et al.*, 2008). The results obtained in this study are in agreement with the above statement. The mean ulna length in our study group was longer in males than in females. This was in agreement with a previous study conducted on Uromi, Edo state (Ebite *et al.*, 2008). There is distinct sexual dimorphism in the ulna length of a population.

Correlation coefficient between total height and ulna length was found to be statistically significant and positive indicating a strong relationship between the two parameters. Regression equation for stature estimation was formulated using ulna lengths and checked for their accuracy by comparing the estimated stature and the actual stature. The results indicate that ulna length provides an accurate and reliable means in estimating the stature of an unknown individual. Furthermore, regression equation of height on ulna length has definitive advantage over that of tibial length, as it can be useful in cases where the lower extremities are deformed along with the deformities of the trunk (Joshi *et al.*, 1964).

Height estimation has also been attempted using the ratio between height and ulna length (Ebite *et al.*, 2008). Results obtained from a study that attempted to reconstruct stature from ulna length in Hindu population in Gujarat state demonstrated a regression coefficient between height and ulna length to be +3.506 for males (Joshi *et al.*, 1964). The present study shows a regression coefficient of +2.645 for males and +3.536 for females. These formulae are valid for the age group (20-23 yrs) of the current study population.

Estimation of an individual's height is an important parameter in forensic examinations and anthropological studies. Many factors like, racial, ethnic and nutritional factors affect human development and growth and therefore, different nomograms are required for different populations (Williams *et al.*, 2000; Joshi *et al.*, 1964).

To the best of our knowledge, this study for the first time provides norms for height and ulna length in a young adult Sri Lankan population. Taken together the evidence suggests that the relationship between ulna length and height is of practical use in medico-legal, anthropology and archeological studies where the total height of a subject can be calculated if the ulna length is known.

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