Original Research Article

Estimation of stature of an individual using ulnar length among Trichy population

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Abstract

Background: Anthropometric characteristics have a direct relationship with sex, shape, and form of an individual, and these factors are intimately linked with each other and manifestation of the internal structure and tissue components which in turn are influenced by environmental and genetic factors. It is a fact especially familiar not only to anatomists but also to artists that trunk and limbs exhibit consistent ratios among themselves and relative to the total height. The ratios are linked to age, sex, and race.
Aim of the study: To find out the correlation between ulnar length with the stature of an individual.
Materials and methods: This prospective study was conducted in the Institute of Forensic Medicine, Department of Forensic Medicine, K.A.P. Viswanatham Government Medical College, Tiruchirappalli from January to 2020 to September 2020. The descriptive component to find out mean heights ulnar lengths of both hands of male and female study participants. The analytical component was used to evaluate the correlation between the height and length of ulna bone and to arrive at a regression equation for height with a length of the ulna in both sexes.
Results: The mean ages of the study subjects (Male 21.184 ± 3.27 and Female 21.01 ± 3.31) were not significantly different between genders. Significant (P< 0.05) Gender differences in mean height and length of the ulna were found in the study. Mean right and left ulna lengths of the male (26.614±2.92 and 26.492±2.85) were significantly larger than that of the females (24.944±2.64 and 24.780±2.58) of all ages significantly larger than that of the females of all ages.
Conclusion: In the present study, an attempt was made to document a relationship between the ulna and height in the Indian population. There was no statistically significant difference between the right and left ulna. A positive correlation was found between stature and length of the ulna. A simple linear regression equation derived can be used for the estimation of height from the ulna and vice versa.

Key words

Anatomist, Anthropologist, Anthropometry, Human stature, Ulna.

Introduction

Estimation of stature has significant importance in the field of forensic medicine and anthropometry. Anthropometry is a series of systematized measuring techniques that express quantitatively the dimensions of the human body and skeleton [1]. The ultimate aim of using anthropometry is to help the law enforcement agencies in achieving ‘‘personal identity’’ in case of unknown human remains [2]. Establishing the identity of an individual from mutilated, decomposed, and amputated body fragments has become important in recent times, due to natural disasters (such as earthquakes, tsunamis, cyclones, and floods) and man-made disasters (such as terror attacks, bomb blasts, wars, and plane crashes). It is important for both legal and humanitarian reasons [3]. The ulna is a long bone on the medial side of the forearm. Proximally it has an olecranon process, and at its distal end is a styloid process. The whole length of the subcutaneous border of the ulna is palpable down up to the styloid process [4]. The length of the ulna is a reliable and precise means of predicting the stature of an individual. In 1952, Trotter and Gleser published a definitive study on stature calculation for American whites and blacks. Data used were from the cadavers of World War II and the Terry Collection [5]. All six long bones were measured for maximum length along with the maximum length of the femur, and tibial length between upper and lower articulating surfaces. Different equations for the estimation of stature were established for whites and blacks, and males and females [6]. The equations that were derived by Trotter and Gleser in early 1950 for Americans were being continuously revised using data from different sources. In 1977, they proposed new equations using radius and ulnar length. In 1961, Allbrook attempted to develop standards for the estimation of stature from a British sample using ulnar length, which was measured from ‘‘the tip of the olecranon process to the distal margin of the head” with forearm flexed and semipronated and hand in the natural position [7]. Stature or body height is one most important and useful anthropometric parameters that determine the physical identity of an individual. In anthropometric research, the prediction of stature occupies relatively a central position [8].

Materials and methods

This prospective study was conducted in the Institute of Forensic Medicine, Department of Forensic Medicine, K.A.P. Viswanatham Government Medical College, Tiruchirappalli from January 2020 to September 2020. The descriptive component to find out mean heights ulnar lengths of both hands of male and female study participants. The analytical component was used to evaluate the correlation between the height and length of ulna bone and to arrive at a regression equation for height with a length of the ulna in both sexes. Inclusion criteria were male or female healthy medical and paramedical students of age (18-22) years subjects with skeletal abnormalities like achondroplasia, polio, scoliosis, previously fractured forearm, amputated upper limb were excluded out from the study. Measurements were taken using standard anthropometric instruments namely vernier calipers and stadiometer. Length of ulnar was measured with the help of Vernier caliper from the tip of olecranon process to tip of the styloid process with the forearm flexed 90* and hand touching the opposite shoulder for both sides. Height was measured in standing position with barefoot in the stadiometer with the head oriented in Frankfurt plane. Measurements were taken by sliding the horizontal part to the vertex in the sagittal line. All measurements were taken around 2 to 4 PM to avoid diurnalvariation.

Statistical analysis

Data entry and analysis were done using Statistical Package for Social Sciences – Version 16.0. Descriptive statistics (the number and

percentage) of the background variables were calculated. (T) the test was used to find out the association between right and ulna concerning gender. ANOVA test was done to find out the correlation. The regression equation was derived at and a p-value of <0.05 was considered significant.

Results

The observations were analyzed separately for both right and left ulna in each sex on all subjects and results are tabulated. The mean ages of the study subjects (Male 21.184 ± 3.27 and Female) 21.01 ± 3.31) were not significantly different between genders. Significant (P< 0.05) Gender differences in mean height and length of the ulna were found in the study. Mean right and left ulna lengths of the male (26.614±2.92 and 26.492±2.85) were significantly larger than that of the females (24.944±2.64 and 24.780±2.58) of all ages significantly larger than that of the females of all ages (**Table – 1, 2, 3**).

Table – 1: Mean height of total subjects.

Parameters (cm)	Mean	SD
Height	162.092	10.14
Length of Ulna (right)	25.787	2.89
Length of Ulna (left)	25.645	2.85

Table – 2: Mean height of male subjects.

Parameters (cm)	Mean	SD
Height	168.020	9.76
Length of Ulna (right)	26.614	2.92
Length of Ulna (left)	26.492	2.85

Table – 3: Mean height of female subjects.

Parameters (cm)	Mean	SD
Height	156.044	6.21
Length of Ulna (right)	26.492	2.85
Length of Ulna (left)	24.780	2.58

Table - 4 shows a Comparison of the right and left ulna. From **Table - 4**, it is found that the mean value of the length of right and left ulna of the study group is statistically insignificant in males, females, and both together (P >0.05). So for further statistical analysis, the Length of the left ulna will be considered, as per the recommendation of the international agreement for paired measurements at Geneva (1912). **Table - 5** shows that the correlation of height with the length of the ulna is 0.86 in males, 0.58 in females, and 0.75 in both together, which are positive and statistically highly significant (P < 0.01) i.e. if the length of ulna increases or decreases, the height of the subject also increases or decreases and vice versa. **Table - 6** shows the linear regression equation for height with a length of the ulna in male, female, and both together, where, Y = Height/ Stature (cm) X = Length of the ulna (cm) 93.54, 90.57, 121.52 are intercepted (constant) for male, female and both together respectively. 2.67, 2.92, 1.39 were regression coefficients for male, female, and both together. From the result, it was seen that the regression formula within a region also varies between the male and female populations of that region. Positive correlation of Length of Ulna (Mean = 25.65 cm) on X-axis and Height of subjects (Mean = 162.09 cm) on the y-axis, indicating that increase in length of ulna leads to an increase in the total height of male subject (r = 0.75, P<0.01). The significant correlation was further interpreted by linear regression. 56.4% variation observed in height is due to the increase in length of the ulna. (r^2 = 0.56) shows a positive correlation of Length of Ulna (mean = 26.49 cm) on the X-axis and Height of male subjects (mean = 168.02 cm) on the y-axis, indicating that increase in length of ulna leads to an increase in the total height of male subject (r= 0.58, P<0.01). The significant correlation was further interpreted by linear regression. 42% variation observed in height is due to the increase in length of the ulna. (r^2 = 0.34). Positive correlation of Length of Ulna (mean = 24.78 cm) on X-axis and Height of female subjects (mean = 156.04 cm) on the y-axis, indicating that increase in length of ulna leads to an increase in the total height of male subject (r = 0.86, P<0.01). The significant correlation was further interpreted by linear regression. 42% variation observed in height is due to the increase in length of the ulna. (r = 0.73).

Table – 4: Comparison of length of right and left ulna.

Subject	Z value	P-value
Both sexes together	0.62	>0.05
Male	0.76	>0.05
Female	0.69	>0.05

Table – 5: Pearson's correlation coefficient.

Subjects	Correlation Coefficient (r)	Coefficient of determination (%)	P value
Both sexes together	0.75	56.4	< 0.01
Male	0.86	73.1	< 0.01
Female	0.58	33.6	< 0.01

Table - 6: Regression equation for height with length of ulna in male, female and both sexes together.

Subjects	Correlation Coefficient (r)	Regression equation	P value
Both sexes together	0.75	Y = 93.54+ 2.67X	< 0.01
Male	0.86	Y = 90.57+ 2.92X	< 0.01
Female	0.58	Y = 121.52+1.39X	< 0.01

Discussion

The sex determination of an unknown individual and the estimation of stature is one of the most important aspects of forensic medicine and anthropological studies. Estimation of stature is essential for the calculation of body mass index, which is used for the assessment of nutrition. However, its measurement is not always practical in old or frail bedridden patients who cannot stand or those who are suffering from vertebral column deformities [9]. In such patients, formulae based on the ulna length provide an alternative stature predictor. Pan worked on cadavers and derived a relation between the total ulnar length and a total height of an individual. According to Trotter M et al., there is an increase in the height of 2.5 cm after death [10]. Hence prediction of height using ulna in living has a definitive advantage over the cadavers. Various authors have observed that there is secular change and allometry between sexes among the population. As the rate of skeletal maturity in males and females tends to vary during development, gender-specific formulae are required for the estimation of height [11, 12]. In the present study, there was no statistical difference between the length of ulna between males and females. The Correlation coefficient between the total height and ulna length was found to positive indicating a strong relationship between the two parameters. The positive correlation suggests if the length of the ulna increases or decreases, the height of the subject also increases or decreases and vice versa [13]. The present study deals with observations on the correlation of total standing height with the length of the ulna. In anthropological studies and forensic examinations, prediction of stature from incomplete and decomposing skeletal remains is important in identifying an unknown individual. The stature of an individual mainly being genetically predetermined is an inherent characteristic that needs to be estimated for the identification of an unknown individual. Therefore, formulae based on the length of ulna provide an alternative stature predictor under such circumstances. The ulna has easily identifiable surface landmarks making the measurement possible [14]. However, this was unlikely to be a problem in our study as the trained principal investigator himself performed the measurements in all subjects with the help of another female doctor who was also trained

personally by him; hence the test was not read by multiple independent observers [15]. The average height of adult males within a population is significantly higher than that of adult females. The result obtained in this study is in agreement with the above statement. Studies on secular changes and algometry have demonstrated different limb proportions between sexes and among the population. As the rate of skeletal maturity in males and females tend to vary during development, gender-specific formulae are required for the estimation of height [16]. In the present study, there was no statistical difference between the length of right and left ulna both within each gender and between males and females [17]. Our current study goes on to prove that there was no significant difference in the lengths of ulnar bone between males and females. They claimed that the ulnar multiplication factor is a better guide for the calculation of height when it is not known to which part of the country the individual belongs [18, 19, 20].

Conclusion

The mean height and length of the ulna are more in males than in females. Gender differences in mean height and length of ulna were found to be highly significant (P <0.05). There is a positive correlation between stature and length of the ulna. If either of the measurement (length of ulna or total height) is known, the other can be calculated. Thus the data of this study will be of practical use in Medico-legal investigations and anthropometry. Hence the present study would be useful for Forensic Medicine experts and Anthropologists.

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