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Anatomy

Length of Ulna and Its Correlation with Stature in Nepalese Population

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Abstract | **Original Research Article**

Introduction*:** Stature, an individual inherent characteristic, is an important measurement of physical identity. Percutaneous measurement of length of ulna, amongst sundry methods, can be quantitatively used to express height, and has been carried out in Nepalese population in this study. ***Method*:** A cross-sectional, descriptive study was conducted in 198 randomly selected healthy peoples, aged 19-25 years, attending outpatient department at Lumbini Medical College, Palpa, Nepal. Length of bilateral ulna, from tip of olecranon to the tip of styloid process, in flexed elbow, and height of each induvial participant were measured in standard position (Frankfurt plane). Means and standard deviations of all variables were recorded and tabulated; and regression equations were calculated for estimating height across each diverse subsets of participants. ***Results: A significant correlation was found between ulnar length and stature (right ulna male: 22.98±1.29cm; right ulna female: 23.21±1.92cm; left ulna male: 22.85±1.30; left ulna female: 23.10±1.95; mean height in males: 153.98±1.29; mean height in females: 151.67±1.92). ***Conclusion:*** Being a percutaneous and easy to measure bone, ulnar length can be an infallible technique for estimating an individual's height, thus becoming nifty for anatomists, anthropologists, and forensic experts.

Keywords: Stature estimation, ulna, regression equation, Nepal, bone length.

INTRODUCTION

Correlation between different body parts to stature has been an inquisitive area of research for medical scientists, anthropologists, forensic experts, and for humanitarian and legal reasons [1]. The age, sex, and height of an individual are three different characteristics that mostly reveal the identity of an individual. Stature is the natural height of a person from foot to vertex, in anatomical position, in Frankfurt plane [2]. It can be measured directly or estimated from anthropometric measurements of various bones, spinal column, arm span, head length and breadth [3], clavicle [4] as well as foot dimensions [5]. Since ancient times, different scientists have put forward different equations across the globe to estimate the height of different groups of populations by using different parts of the skeleton [6]. While calculating living stature from bone lengths, regression method has been used as the most convenient method, and was formulated by Pearson [7, 8]. However, formula devised for one population cannot be reliably used on other populations because stature is swayed by multiple factors like sex, age, race, heredity, climate, nutritional status, social stratum, and secular trend [9]. Allbrook *et al.*, standardized the estimation of height from ulnar length in 1961 [10]. Similarly, Krogman and colleagues elucidated about estimation of stature from skeletal remains [11]. The purpose of this study is to correlate the length of ulna to height in a subset of Nepalese population.

MATERIALS AND METHODS

A descriptive cross-sectional study was carried out in 198 randomly selected healthy peoples of age 19-25 years from 2013 May to 2014 April from outpatient departments at Lumbini Medical College. Height and length of bilateral ulnae were measured in participants after verbal consent and information about the procedure. Those with any apparent physical disability or visible deformity of the skeleton and those who didn't volunteer were excluded from the study. Institutional Ethical Committee permission was obtained in accordance with Ethical standards laid down in Helsinki declaration of 1964.

All the participants underwent measurement of height from the same stadiometer following standard anthropometric protocols [12]. Ulnar length was measured from the tip of olecranon process to the tip of

styloid process, with elbow flexed and palm spread over opposite shoulder [13], and with the help of same measuring tape. Measurement of length of right and left ulna was taken separately for calculation. Measurements were done at 12-2 pm each day to avoid any diurnal variation in height [14]. All measurements were recorded by the same investigator to avoid any personal error in methodology.

The collected data of ulnar length and respective height were analyzed statistically by using Microsoft Office Excel 2013 (Microsoft Corporation, Redmond, WA). The mean and standard deviations (SD) of the data were calculated for both anthropometric variables. A comparison of the mean of body height and ulnar length between the sexes was carried out using a student t-test. The relationship between body height and ulnar length was determined by the Pearson correlation coefficient. Significance was assumed for $p < 0.05$.

RESULTS

Of the 198 participants 89 (44.95%) were males and 109 (55.05%) were females. Age of the patients ranged from 19 to 25 years. The height and ulnar length of both right and left side in males (157.9± 6.23 cm; 24.23 ± 0.97cm; and 24.07± 0.81 cm, respectively) were found to be significantly ($p < 0.001$) higher than in females (149.60± 2.90 cm; 22.53± 0.55 and 22.29 ± 0.55 cm, respectively)

Table 1: Anthropometric measurements in male and female participants

	Male			Female			p-value
	Range	Mean	SD	Range	Mean	SD	
Height	155-169	157.9	6.23	145-155	149.60	2.90	<0.01
Length of right ulna	23.3-25.1	24.23	0.97	21.0-23.6	22.53	0.55	<0.01
Length of left ulna	23.2-25.0	24.07	0.81	20.9-23.5	22.29	0.55	<0.01

Correlation and regression analyses between body height and length of right and left ulna revealed positive correlation amongst variables in both males and females.

Table 2: Correlation and regression analysis between body height and ulnar length among male and female study subjects

Parameters	Male	Female
Correlation coefficient	0.91	0.93
Regression equation (right ulna)	Height = 5.9 * ulnar length+ 23.7; R^2 = 0.92	Height = 5.87 * ulnar length +15.3; R^2 = 0.87
Regression equation (left ulna)	Height = 5.8 * ulnar length +24.2; R^2 = 0.89	Height = 5.79 * ulnar length +14.9; R^2 = 0.91

All the correlation coefficients were found to be statistically significant ($p < 0.001$). Thus, the length of the ulna is positively and significantly related to the height of the participants.

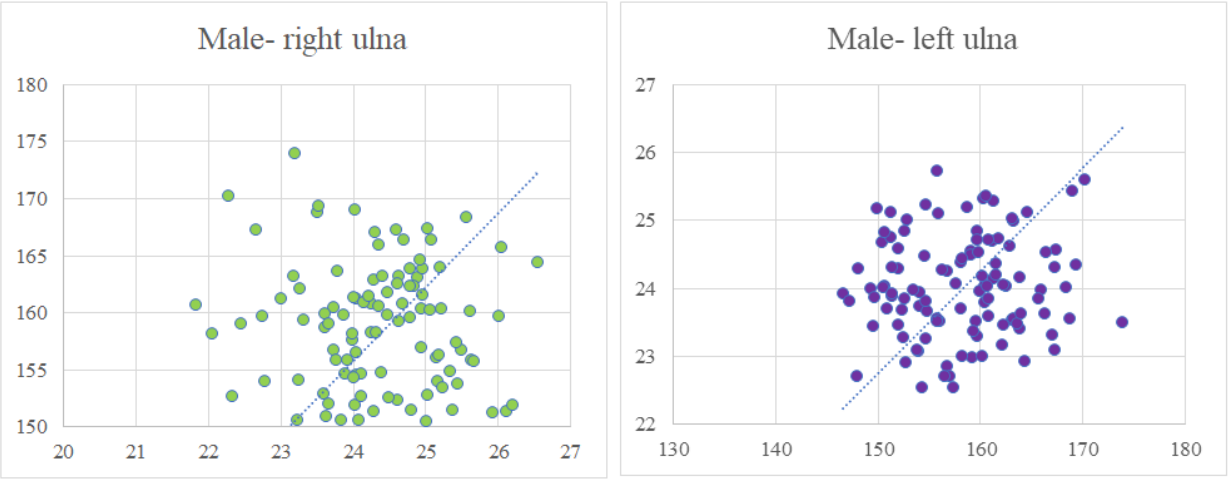

Figure 1: Scatter diagram in male subjects (a) right ulna (b) left ulna

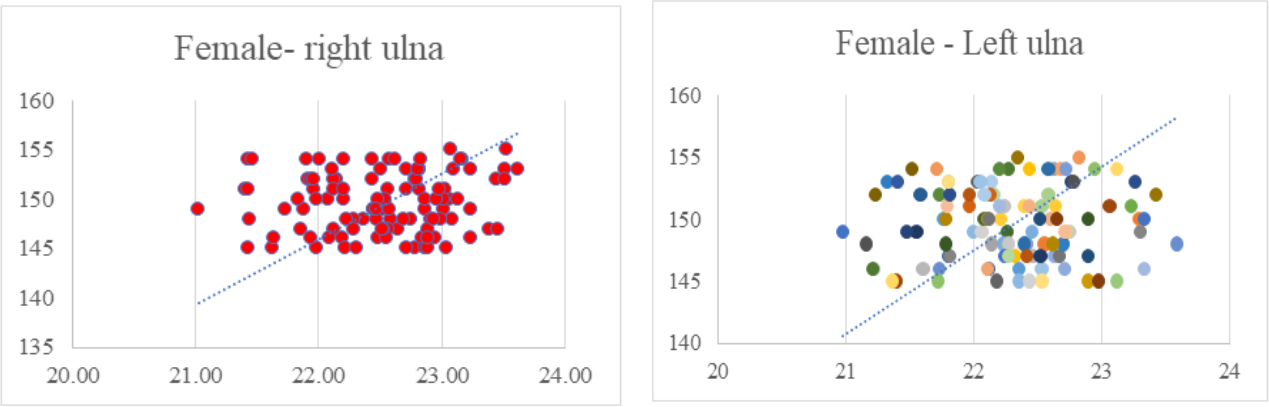

Figure 2: Scatter diagram in female subjects

DISCUSSION

Height and ulna length significant or not Estimation of stature is one of the most vital aspects in forensic medicine and anthropology [15]. Researchers throughout the globe have used various long bones like femur, tibia, humerus, ulna, forearm length as well as arm span for estimating height of an individual. However, ulnar length is facile and superior than arm span [16] and length of hand [17]. In this study males were found to be taller than females, which is akin to the findings of N. Pandey *et al*., [18], A. Pandey *et al*., [19], and Ebite *et al*., [20]. Similarly, length of ulna in both males and females were comparable to the findings of Bamne *et al*., [21], Prasad *et al*., [22], and Gul *et al*., [23]

Regression formula obtained in this study resembles the finding of Sarma *et al*., [6]. And various other findings from around the globe have been tabulated below.

Table 3: Comparison of Linear regression equations of other studies

Author	Place	Subjects	Regression equation
Athawale *et al*., [24]	Maharastra	Male	Stature = 56.79 + 3.96 X length of right and left ulna
Borhani-Haghighi *et al*., [25]	Iran	Males and females	Stature = 81.89 + 3.13 x Left ulnar length (cm) ± 4.37
Barbosa Vm *et al*., [26]	England and Portugal	Male and females	Stature = 84.7 x 3.2 ulna length (cm) for males and 78.5 x3.3 ulna length (cm) for females
Choi B. Y *et al*., [27]	Korea	Male	Stature = 70.78 + 3.74 x length of ulna± 4.97
Mall G *et al*., [28]	Germany	Male and female	Stature (male) = 90.48 + 3.14X1± 7.5; Stature (female) = 44.82 + 5.01X1± 7.5

The use of the regression equation plays pivotal role in those individuals where erect height cannot be calculated in a direct way like in limb deformities, amputated legs or shortening of lower limbs, various spinal column deformities, or in bedridden patients.

Although approximation of height by regression equations are superior to multiplication factors, they might not be always accurate [29]. However, ulnar length will suffice as a good anthropometric parameter in most situations.

CONCLUSION

As per this study, there is a linear relationship between height and length of ulna in an individual. The use of regression equation can hence be used to estimate stature in Nepalese population and will be beneficial to anatomists and wide groups of professionals.

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