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Original Article

Estimation of Stature from Percutaneous Length of Radius and Ulna in Nepalese Medical Students

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Abstract

Background

Stature estimation is an integral part of forensic identification along with race, sex and age. The relevance is greater when decomposed, mutilated and burnt bodies are brought for autopsy. Previous studies have shown isolated body parts and bones reasonably accurate in estimating stature. Present study aims at estimating stature from percutaneous lengths of radius and ulna in Nepalese medical students.

Material and Methods

A cross sectional study was conducted from April 2024 to September 2025 in Nobel Medical College Teaching Hospital, Nepal; including 412 Nepalese medical students (182 males and 230 females). After taking informed consent; Stature was measured with standard stadiometer, while Percutaneous Radial Length (PCRL) and Percutaneous Ulnar Length (PCUL) were measured by flexible measuring tape using standard techniques. Data was analyzed using Statistical Package for Social Sciences (SPSS Ver. 20) software. Pearson's correlation coefficient was used to find correlation of stature with PCRL and PCUL, and its significance tested by t-test ($p < 0.005$). Linear regression equations were derived to estimate stature from PCRL and PCUL.

Results

Stature showed significant positive linear correlation with PCRL and PCUL in both sexes. The derived linear regression equation for stature estimation for males was 116.478 + 2.108*PCRL and 107.056 + 2.326*PCUL, for females was 104.006 + 2.356*PCRL and 107.228 + 2.087*PCUL and for entire cases was 88.145 + 3.132*PCRL and 86.793 + 2.994*PCUL.

Conclusion

Stature shows significant positive correlation with PCRL and PCUL in Nepalese medical students. Hence stature estimation can be done from PCRL and PCUL in Nepalese context.

Key Words: *Body Height, Human Identification, Radius, Regression Analysis, Ulna*

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Introduction

Anthropometry is the systematic technique of measuring various dimensions of human body and skeleton and has been in use as an invaluable tool of anthropology. In recent times the use of measuring various body parts has gained significant importance in field of forensic medicine especially in context of human identification [1].

Identification is the process of ascertaining individuality of a person. In scenarios where visual recognition and personal artefacts are not useful various parameters like race, age, sex and stature are determined initially followed by more accurate means such as odontology, fingerprint and DNA profiling to ascertain identity. Identification of decomposed, fragmented, mutilated and burnt human remains is even more challenging task for forensic experts and medico-legal investigators. Such cases are usually the results of crimes, disasters and accidents. Stature, which is the upright length from vertex to heel, is one of the crucial parameters that are utilized in segregating such unidentified remains, other than sex, age and race, to facilitate further identification process [2, 3].

Long bones are the major contributor to the stature of humans. Estimation of stature from long bones' measurements has been found to be reasonably accurate in various populations of the world. Each population has shown to exhibit different relationship between stature and long bones based on geography, genetics, nutrition etc. which demands population specific studies.Though lower limb bones are greatest contributors of height of a person, bones of the forearm such as radius and ulna have easily palpable landmarks so they are even more useful and reliable for forensic identification scenarios [4, 5].

Present study aims at estimation of stature from Percutaneous Radial Length (PCRL) and Percutaneous Ulnar Length (PCUL) in Nepalese medical students as there are negligible studies done previously in Nepalese population. The result of this study is expected to add to forensic medico-legal work and literature in Nepal [6].

Materials and Methods

This was a prospective cross-sectional study done in Forensic Medicine Department of Nobel Medical College Teaching Hospital; Biratnagar, Nepal from April 2024 to September 2025. Ethical clearance for the study was taken from Institutional Review Committee of the same institution (IRC-NMCTH 23/2024). The sample size was calculated using, $n=z^2p(1-p)/e^2$. Where, z=1.96 (95%confidence limit), p=0.5(50% population proportion) and e=0.05 (5% allowable margin of error). The minimum sample size was estimated to be 385. However, 412 Nepalese medical students over 20 years of age were included in the study because in all the long bones, secondary epiphyseal centers fuse with shaft rendering static height after 20 years. Informed expressed consent was obtained prior to enrollment of participants in the study.

Stature (standing height) of the person was measured in centimeters (cm) using a standard stadiometer. Percutaneous lengths of radius and ulna were measured on both the sides and average of two sides was taken as final measurement for each bone. Flexible measuring tape was used for taking the measurement in centimeters (cm). Persons having history of fracture of radius or ulna, visible deformity of forearm and recent injuries over forearm were excluded.To measure the length of the ulna, forearm was maintained in full pronation with fingers extended and touching each other. The distance between the most proximal point of the olecranon and the tip of the styloid process of the ulna was measured in centimetres (cm) and recorded as percutaneous length of ulna (PCUL).To measure the length of the radius, forearm was maintained in mid pronation with fingers extended and touching each other. The distance between the most proximal point of the radius head and the tip of the styloid process of the radius was measured in centimetres (cm) and recorded as percutaneous length of radius (PCRL).

The data was recorded in standard proforma and entered in Statistical Package for Social Sciences (SPSS) Ver. 20 for statistical analysis.To assess the correlation between the stature with PCRL and PCUL, Pearson's correlation coefficient was calculated and its significance was tested by t-test. P-value of less than 0.05 was considered significant. Linear regression equations were derived to estimate stature from the PCRL and PCUL for entire cases as well as for males and females separately.

Results

Out of 412 cases included in the study 182 (44.17%) were males and 230 (55.83%) were females. Age of the participants was between 20 to 26 years. The mean stature, mean PCRL and mean PCUL for entire cases were 163.3155$\pm$ 8.35 cm, 23.9988$\pm$1.84cm and 25.5580$\pm$1.96cm respectively. All measurements were greater in males compared to females and the differences

were statistically significant ($p<0.05$). The descriptive statistics are presented are presented in Table 1.

Table 1: Descriptive statistics for stature, PCRL and PCUL

Sex	Variables	Stature (cm)	PCRL(cm)	PCUL(cm)
Male (N=182)	Mean	169.2473	25.0357	26.7324
	Std. Deviation	5.9815	1.4919	1.4718
	Minimum	156	19.20	21.10
	Maximum	182	28.70	29.80
	Range	26	9.50	8.70
Female (N=230)	Mean	158.6217	23.1783	24.6287
	Std. Deviation	6.8471	1.6683	1.7863
	Minimum	141	19.20	19.90
	Maximum	177	27.30	28.90
	Range	36	8.10	9.0

The scatter diagram shows a strong, linear and positive correlation between percutaneous length of radius and ulna with stature, for both males and females in Fig 1 and Fig 2.

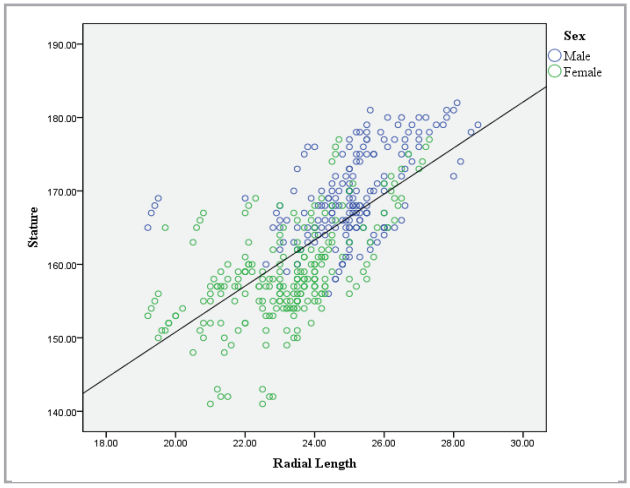

Figure 1: Scatter diagram showing correlation of stature and PCRL

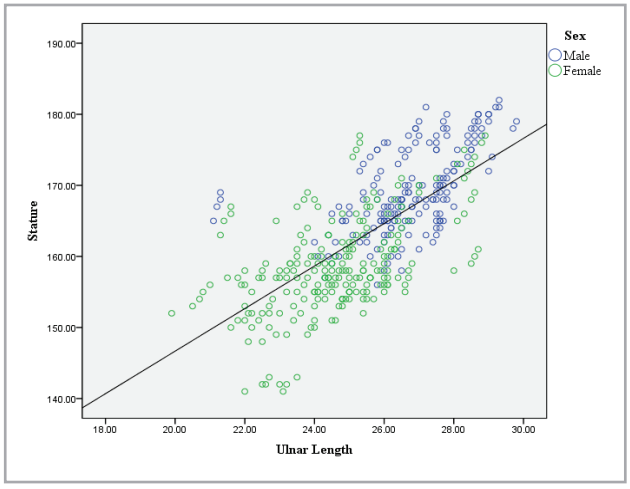

Figure 2: Scatter diagram showing correlation of stature and PCUL

Pearson's coefficient (R) showed significant positive correlations of stature with PCRL and PCUL both in males and females, as well as for entire cases ($p < 0.001$). The relevant statistical values along with the regression equations are presented in Table 2.

Table 2: Regression analysis of stature with PCRL and PCUL

Statistical parameters	Regression equation Stature (cm) =	Coefficient of Correlation (R)	Coefficient of determination (R^2)
Males	116.478 + 2.108*PCRL	0.526	0.276
(N=182)	107.056 + 2.326*PCUL	0.572	0.328
Females	104.006 + 2.356*PCRL	0.574	0.330
(N=230)	107.228 + 2.087*PCUL	0.544	0.296
Total cases	88.145 + 3.132*PCRL	0.690	0.476
(N=412)	86.793 + 2.994*PCUL	0.701	0.491
	P < 0.001		

Discussion

Anthropometry in simple understanding, the measurement of various dimensions of human, is composed of two words 'anthropos' meaning “man” and 'metron' meaning “measure”. Humans exhibit wide variations in their body dimensions and measurements based on age, sex, race, ethnicity, environment, food habits and genetics [7]. Stature, which refers to standing height of a person from crown to heel, is too affected by above mentioned factors. Stature along with race, age and sex is an important component to be sorted out in forensic identification process especially in cases of decomposed, burnt, mutilated and dismembered human remains resulting from road and aviation crashes, disaster or various types of criminal activities. These variations are significant among various populations which demands population specific study and databases for stature estimates from various body measurements, because the reference ranges and regression equations derived for one population may not give accurate and reliable results for another population. Similarly data bases derived from living samples differ from those derived from skeletal samples or corpse with intact soft tissue [8, 9].

Estimation of stature can be done by either anatomical method, which applies to full set of skeleton or complete human remains available or by mathematical method which search for association of any particular long bones of the body to estimate stature through regression equations. The former provides better result than

later one but the nature of forensic samples for identification constitutes, most of the times, a part of human skeleton and few isolated bones. Hence using regression equations to predict stature from long bones have been immensely useful medico-legal identification purposes all over the world. Long bones of upper limb have been found to be as accurate as that of lower limbs in predicting the stature through regression equations in various populations [10-12].

In present study the forearm bones, namely radius and ulna, measured percutaneously predicted stature with reasonable accuracy in both males and females as well as for all the cases ($R > 0.5$ at $p<0.001$ for all the groups). The regression equation showed PCRL (R=0.574) to be more accurate than PCUL (R=0.544) in females for estimating stature. For males PCUL (R=0.572) was more accurate than PCRL (R=0.526). For total cases PCUL (R=0.701) showed higher accuracy than PCRL (R=0.690) in estimating stature. Overall predictability was greater in females than males. A study done by Potdar A et al. (2019) in India involving 200 medical students showed similar results showing even stronger correlation (R=0.83) of forearm bones with stature [13]. Another study done by Ilayperumal I et al. (2010) in Sri Lanka including 258 cases showed similar significant correlation between length of forearm and stature [14]. Similar were the findings of Bal K and Bapuli C (2022), where they revealed in 200 medical students in Kolkata, India that there was significant correlation between length of forearm and stature in both sexes. The mean stature for male and female students was 168.97±6.33cm and 158.64±5.28 cm respectively which was almost identical to present study (Male 169.25±5.98 and Female 158.62±6.85). These findings suggest a similar pattern of growth and morphology between Nepalese and Indian population [15]. Another study done by Boonthai W et al. (2024) in Northeastern Thailand population involving 400 males and 400 females dry bone samples showed higher correlation of forearm bones with stature in males than with females (Ulna: R=0.670; Radius: R=0.663) compared to females (Ulna: R= 0.402; Radius: R=0.393), concluding stature can be accurately estimated from forearm bones. The findings contradict with present study where there is mixed accuracy. [16] Similar results were seen in study done by Celbis O and Agritmis H (2006) where they studied Turkish corpse samples for stature estimates from forearm bones [17].

Minimal studies in this topic have been conducted in Nepal. Yadav BP et al. (2023) had conducted similar study in 125 undergraduate student of Gandaki Medical College, Nepal. They found significant correlation between PCRL with stature with higher correlation coefficients than present study(R=0.782 for males and R=0.716 at $p<0.001$) [18]. Similarly, Shah RP et al. (2018) studied on 150 patients and visitors of MB Kedia Dental College, Birgunj, Nepal and found out PCUL having significant correlation with stature (R=0.55 for left ulna and R=0.46 for right ulna at $p< 0.001$) [19]. These studies suggest that both radial and ulnar length can be taken as good predictor of stature in forensic identification scenarios. Further similar studies in this regard are necessary with larger sample size for Nepalese population in various age groups and ethnicity, in both living and dead to add to medico-legal database and literature for future utility in relevant context.

Conclusion

Stature shows significant positive correlation with Percutaneous Radial Length (PCRL) and Percutaneous Ulnar Length (PCUL) in Nepalese medical students. Hence stature estimation can be done with reasonable accuracy from PCRL and PCUL in both sexes which can be helpful for forensic identification process in Nepalese context. The result of this study is expected to add to further such studies done in Nepalese population in future.

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