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Stature estimation measuring per-cutaneous length of ulna in living subjects

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Abstract

Background: Estimation of stature from bones play an important role in identifying unknown bodies, parts of bodies or skeletal remains. Multiple anthropometric techniques have been used to estimate stature from skeletal remains by anthropologists, anatomists & forensic experts. Since olecranon process and styloid process of ulna are easily felt through the skin, it becomes easy to measure the length of the bone.

Objectives: This study was carried out to investigate the relationship between stature and ulna length and to derive a regression formula between the ulna length and height of an individual.

Materials and Methods: 300 subjects (150 males & 150 females) aged between 21 and 25 years were included in this study. Measurements of ulna length were taken by using Dividing Calipers and the height was recorded using Stature meter. The data was subjected for statistical analysis using SPSS software

Results: A positive correlation between height and ulna length was observed in both sexes and it was statistically significant. Regression equation for stature estimation was formulated using the ulna length for both sexes.

Conclusion: Since simple and easily applicable methods are involved in the determination of stature, it is widely used. The present study thus helps in establishing identity of an individual when only some remains of the body are found as in mass disasters, bomb explosions and accidents.

Keywords: Dividing calipers, Height, Regression equation, Ulna length, Anthropometry

Introduction

Thousands of people die from war; floods, tsunami &landslides and bomb blasts worldwide. Identification of victims on a large scale earlier was done by DNA sample tests. Even after providing samples of tissue & blood of the closed relatives of the missing persons, the victim cannot be identified. Thus identifying exhumed remains is a challenge to forensic experts. In such case identification is done from physical characteristics such as colour of iris, hair, size and height.

Identification is determining the individuality of a person based on certain physical characteristics. It may be complete (absolute) or incomplete (partial). By partial identification only some facts about identity are known whereas by complete identification absolute individuality of a person can be fixed.

The primary characteristics of identification are age, sex and stature. Stature can be estimated from skeleton. Thus the assessment of stature is considered to be important in identifying unknown human remains.[1]

The dimensional relationships between different body segments to stature have been studied by artists, scientists, anatomists, anthropologists and forensic experts. The rules of body proportions have been made by the artists using dimensional relationships in depicting ideals of beauty in their creations.[2]

The body segments considered for the estimation of stature are foot, hand, upper limb, length of forearm with hand, head length, head height, distance between sternal notch and pubic symphysis are few to name.

In circumstances where only mutilated leg or forearm portions are available of a deceased person, it becomes a challenge to formulate accurate regression models for estimation of height. Accurate results are derived using regression formula measuring long bones. Since ulna is subcutaneous throughout its length and is easily palpable for measurement, it has been selected for the present study.

This study was done to estimate the stature of an individual from the length of ulna. Stature meter was used to measure height of an individual and dividing caliper to measure ulna length. Linear regression equations to calculate height from ulna was derived from the present study.

Materials and Methods

The subjects for the present study were students from various institutions of H.K.E. Society, Gulbarga aged between 21 and 25 years. Total numbers of subjects studied were 300 (150 males & 150 females). Body height and percutaneous ulna length were recorded for each subject.

Height was measured by stature meter fixed to the wall. The subject was measured without shoes bare feet. The subject was made to stand against the wall and directed to hold himself erect without unusual stretching. The arms hang loosely by the body. The heels, sacral region and the upper part of the back touched the wall, neck stiff, chin slightly drawn in and eyes looking straightforward. The stature meter was pulled on the top of the head with sufficient impact to feel the resistance of the bone but without undue pressure downward. The measurement is read from the stature measure.[3]

Ulna length is measured as the straight distance between the most proximal point of the olecranon process to the most distal point of the styloid process in the supinated forearm.[4]

Ulna length was measured with the subject sitting and forearm placed on the table flexed at 90^0 at the elbow. Measurements were taken using dividing calipers in such a manner that the two ends of the caliper were brought to touch proximal point of olecranon process and the distal point of styloid process. The opening of caliper was measured on a separate scale. Undue pressure was avoided while taking measurement.

Measurements were taken during fixed timings of the day between 1 and 3pm to avoid diurnal variation. All measurements were taken by the same observer and with the same instrument to avoid any technical or inter -observer error and to maintain reproducibility. Both height and lengths of right and left ulna were measured separately and were noted in centimetres.

After collection of the data, they were subjected to statistical analysis. Mean, standard deviation, coefficient of variation, correlation coefficient, simple linear regression, regression coefficient and intercept were calculated.

Results

Results were analysed using SPSS 12.0 version software. Initially for summarising data, mean and standard deviation for height and ulna length were estimated and presented in Table 1.

To study the relation between ulna length and stature, the Pearson correlation coefficient for each ulna with stature were estimated and significance was tested through Z test. The results are presented separately for males and females in Table 2.

Constant, Regression coefficient and Variation explained (r^2) of ulna lengths with Stature are presented in Table 3.

Prediction function was derived through linear regression for each ulna measurement with stature for both males and females separately. Table 4

Table 1: Mean Response of Respondents on Ulna length & Height by Gender N= 300

Category	Sample (n)	Right Ulna		Left Ulna		Height (cm)	
		Mean	SD	Mean	SD	Mean	SD
Male	300	28.10	1.2	27.69	1.2	172.13	6.8
Female	300	25.48	1.2	25.05	1.2	157.28	5.8
'Z' Test		**18.57****		**19.31****		20.33**	

**Significant at 1% Level

Table 2: Correlation coefficient between Height and ulna length by gender N= 300

Variables	Males (Height)	Females (Height)
Right Ulna	0.653**	0.641**
Left Ulna	0.671**	0.689**

** Significant at 1% Level

Table 3: Constant, Regression coefficient and Variation explained (r^2) of ulna lengths with Stature in Males & Females

	Varia-bles	Constant	Regression coefficient	r^2	p-value
Males	RUL	69.447	3.654	0.4270	<0.0001
	LUL	64.051	3.902	0.4502	<0.0001
Females	RUL	80.19	3.026	0.4109	<0.0001
	LUL	73.966	3.326	0.4743	<0.0001

Table 4: Regression equation of Height with Right Ulna and Left Ulna by Gender

Male	R^2 Value	Female	R^2 Value
HT = 69.4+3.65 RUL	42.7%	HT = 80.2+3.03 RUL	41.1%
HT = 64.1+3.90 LUL	45.0%	HT = 74.0+3.33 LUL	47.4 %

Table 5: Mean and Standard deviations of the predicted values of stature by regression functions using ulna lengths in Males & Females

	Males		Females	
Height	Mean (cm)	Standard deviation	Mean (cm)	Standard deviation
Observed Ht (cm)	172.134	6.7999	157.2773	5.8177
Predicted Ht by RUL (cm)	172.1244	4.4430	157.2783	3.7295
Predicted Ht by LUL (cm)	172.1155	4.5618	157.2734	4.0065

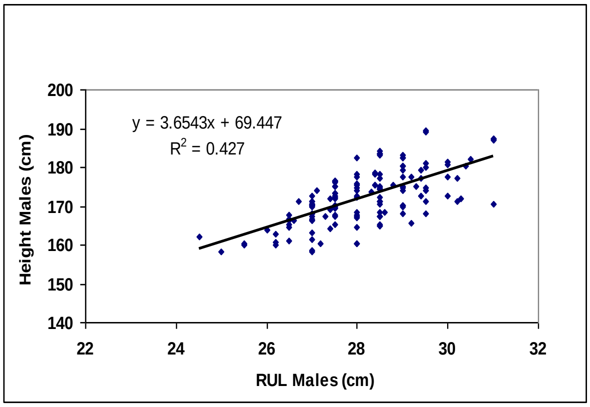

Fig. 1a: Scatter plot and regression line demonstrating relationship between RUL and Height among Males

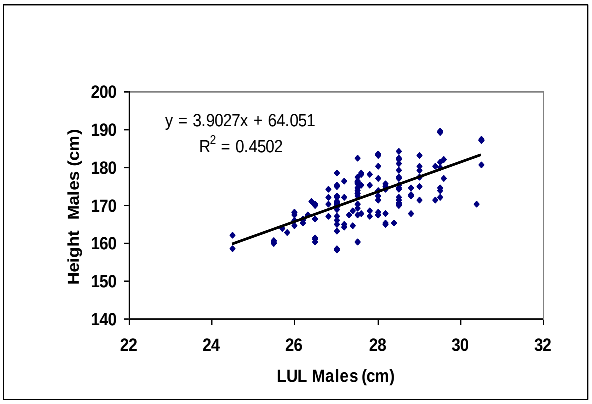

Fig. 1b: Scatter plot and regression line demonstrating relationship between LUL and Height among Males

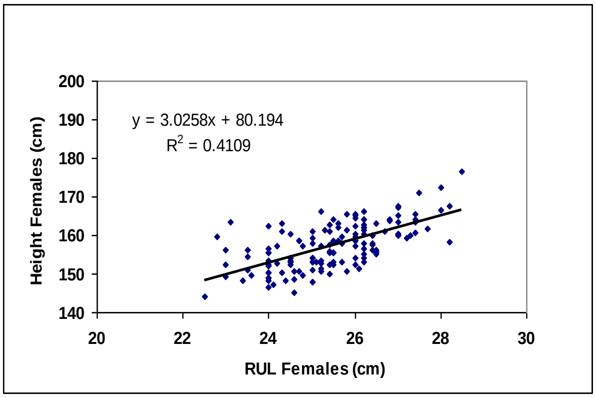

Fig. 2a: Scatter plot and regression line demonstrating relationship between RUL and Height among Females

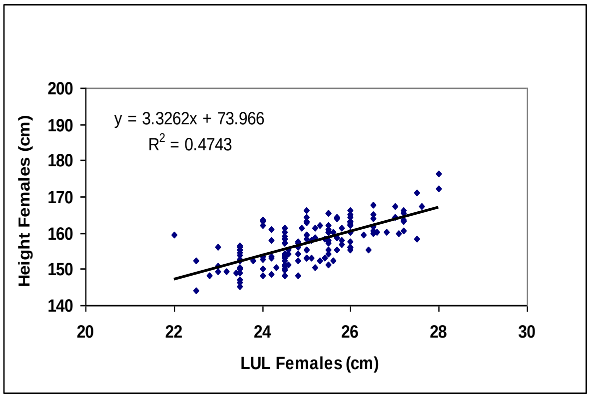

Fig. 2b: Scatter plot and regression line demonstrating relationship between LUL and Height among Females

Discussion

Anthropometry coined by naturalist Georges Cuvier (1769-1832) is a Greek word means the measurement of man.[5] It is a technique used for quantitative expression of human body. It is the systemized art of measuring and taking observations on man, his skeleton, brain for scientific purposes. It is thus considered as the simple, inexpensive, non-invasive method to assess body proportions. Somatometry is the subdivision of anthropometry which means measurement of the body in the living & in the cadaver.[6]

Anthropometry is based on the principle that after the age of 21 years, the dimensions of the skeleton remain unchanged and also the ratio in size of different parts to one another.[7] Alphonse Bertillon was a person who introduced a system of identification in 1883 depending on certain measurements of body parts of human being. It was concluded from the study that when the measurements were recorded systematically then every single individual would be distinguished from the other. Investigating officers adapted this method to fix identity of person and was termed as Bertillonage. The system involves ten measurements: Height, stretch (distance from left shoulder to middle finger of right arm), bust (torso from head to seat when seated), head length (crown to forehead), head width(temple to temple), width of cheeks, length of the right ear, length of the left foot, length of middle finger and length of cubit (elbow to tip of middle finger).[8]

Anthropometry assess in diagnosis of endocrine disorders, assess growth and development and nutritional status. Anthropometric instruments are employed in design of equipment, in the sizing of clothing, shoes and sunglasses and in automotive and airframe construction. In space travel, the techniques of anthropometry are necessary to assure man both comfort and protection.[5]

Height is measured for calculation of body mass index which is which is one of the most commonly used nutritional assessment variable. Its measurement is not always practical in bedridden, elderly people who are incapable to stand or those who are suffering from deformities of the vertebral column.[9]

The development of the stature depends upon a number of factors such as socioeconomic status, climatic condition, sex, age and race of the population.[10] Ulna ossifies by endochondral ossification from four main centers, one each in shaft and distal end and two in olecranon. Ossification begins in the mid shaft about eighth fetal week. The whole proximal epiphysis joins the shaft by 14^{th} year in females and 16^{th} year in males. The distal epiphysis unites with the shaft in the 17^{th} year in females and 18^{th} year in males.[4]

In forensic examinations and anthropological studies, prediction of stature from incomplete and decomposing skeletal becomes vital in establishing the identity of an unknown individual.[11] In such case formula based on ulna length provides an alternative predictor to estimate height. Ulna being easily palpable can be measured even in compromised postures.

Several studies on long bones to measure stature have demonstrated different proportions between sexes which is similar to the present study.[12] Therefore there is a need to derive gender specific formulae as the rate of skeletal maturity in males and females vary during development.[13] The mean stature in the present study is 172.1cm in males and 157.3 cm in females.

Correlation coefficient between total height and ulna length in the present study was in males (r = 0.653, 0.671) and females (r = 0.641, 0.689) for RUL and LUL respectively, which showed positive correlation between height and ulna length.

Gender specific regression formula has been derived from the present study, which is a follows:
Estimated Height in males:

- Height (cm) = 69.447+3.654x RUL (cm)
- Height (cm) =64.051+3.902xLUL (cm)

Estimated height in females:

- Height (cm) = 80.19+3.026xRUL (cm)
- Height (cm) = 73.966+ 3.326xLUL (cm)

Stature estimation methods cannot be universally applied due to the influence of environment among population, modernisation and social economic development between nations and even among people of the same nation. The drawbacks of stature estimation methods can be minimised if stature is estimated from the length of upper limb bones in such diverse conditions among people.[14]

Stature estimates based on long bone measurements require correction factor to compensate for stature decrease in older people. Such a correction factor should exclude the effect of any secular trend in stature and reflect the age at which stature begins to decrease, sex differences and increasing rate of change with age.[15]

If the formula without an age term is used, statures will be underestimated if the age of the individual or mean age of the sample is less than 50 years of age and overestimated if age is over 50 years.[16] The decrease in stature after 30 years due to senile degeneration. Therefore there is a need to derive formula for stature at different age groups to complement this study.

Conclusion

There are various means to establish stature. The simpler the method with more accuracy in estimation wider will be the applicability. There are lot of variations in estimating stature from limb measurements among people of different regions and races. Hence, it becomes necessary to conduct more studies among people of different regions, ethnic groups and different age groups to obtain a simple and reliable method to estimate stature.

The present study shows the usefulness of ulna length in the estimation of stature among individuals aged 21-25years. There is a significant correlation between stature and ulna length from the present study. The regression formula derived from the present study can be used by anatomists, anthropologists, forensic experts in determining height by measuring ulna.

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References

1. Vij K. Textbook of Forensic medicine. Principles and Practice. 3rded. New Delhi: Elsevier India Pvt Ltd;2005:51-52.
2. Sushil K, Srivastava AK and Sahai MKB. Estimation of stature by anthropometric examination of forearm and hand. J Indian Acad Forensic Med 2010 Jan;32(1):62-65.
3. Stewart TD. Hrdlicka's Practical Anthropometry. The Wistar Institute of Anatomy Aand Biology. 4th Ed. Philadelphia;1952:5-6.
4. Standring S. Grays Anatomy- Anatomical Basis of Clinical Practice. 40th ed. Churchill Livingstone. Elsevier;2008:899-902.
5. Warren EP. Encyclopaedia Britannica, USA: Inc. William Benton; 1973:Vol 2:57,58.
6. Stewart TD. Hrdlicka's Practical Anthropometry. The Wistar Institute of Anatomy and Biology. 4th ed. Philadelphia: 1952:5- 6.
7. Reddy KSN. The essentials of Forensic Medicine and Toxicology. 29th ed. Hyderabad: K. Suguna Devi;2010:53,77.
8. https://en.wikipedia.org/wiki/History_of_anthropometry#Bertillon.2C_Galton_and_criminology 14 July 2015.
9. Auyeung TW, Lee JS, Kwok T, Leung J, Leung PC and Woo J. Estimation of stature by measuring fibula and ulna bone length in 2443 older adults. J Nutr Health Aging 2009 Dec;13(10):931-6.
10. Kozak J. Stature reconstruction from long bones, the estimation of the usefulness of some selected methods for skeletal populations from Poland. Variability and Evolution 1996;5:83-94.
11. Ebite LE, Ozoko TC, Eweka AO, Otuaga PO, Oni O and Om'Iniabohs FAE. Height: ulna ratio: A method of stature

estimation in a rural community bin Edo state, Nigeria. The Internet Journal of Forensic Science 2008;3(1).
12. Meadows L and Jantz RL. Allometric secular change in the long bones from 1800s to the present. J Forensic Sci 1995 Sept;40(5):762-767.
13. Williams PL. Grays Anatomy. 38th ed. Edinburgh, London: Churchill living stone; 2000:433-434.
14. Cardoso HF. A test of three methods for estimating stature from immature skeletal remains using long bone lengths. J forensic Sci Jan 2009;54(1):13-19.
15. Giles E. Correction for age in estimating older adult's stature long bones. J forensic Sci 1991 May;36(3):898-901.
16. Raxter MH, Ruff CB and Auerbach BM. Technical note: revised fully stature estimate technique. Am J Phys Anthropol 2007;133:817-818.