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Original Research Article

Estimation of stature from length of arm in adult population of Garhwal region of Uttarakhand, India

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Abstract

Objectives: Stature is defined as the distance between vertex and heel of an individual while standing erect. It can be assessed using dimensions of different body parts. It is an important anthropometric parameter for establishing the identity of a person, especially when fragmentary body parts are found. So the present study was aimed to find the relation between stature and length of arm of an individual and to formulate regression equations for estimation of stature from length of arm of adult population of Garhwal region of Uttarakhand.

Methods: A cross sectional study was conducted in Garhwal region of Uttarakhand. A total of 400 healthy individuals (201 males and 199 females), aged 18-40 years were selected and their stature and length of arm measured. The data was analysed statistically. Correlation coefficient was determined and regression equations formulated. Coefficient of determination and Standard error of estimate were also calculated.

Results: The mean stature was found to be 161.37cm±9.00cm, mean length of right arm was 30.56cm±2.07cm and mean length of left arm was 30.44cm±2.07cm. A highly significant ($p < 0.01$) strong positive correlation was found between stature and length of arm. Regression equations were formulated.

Conclusion: Length of arm showed a highly significant strong positive correlation with stature of adult population of Garhwal region of Uttarakhand. Thus the length of arm is a good predictor of stature of an individual. These finding will help Anthropologists and Forensic experts in estimation of stature from fragmentary body remains and thus to establish the identity of an unknown individual.

Keywords: Personal identification, Anthropologist, Correlation, Regression equation.

1.Introduction

Stature is defined as the distance between the vertex and the inferior surface of heel of an individual. It is influenced by genetic factors, nutrition, growth and development of an individual[1]. It is important in the identification of genetic disorders, to study evolution and comparative anatomy of humans with primates. It is also useful in the field of sports, certain professions and ergonomics[2].

It is an important anthropometric parameter for identification of an individual, especially when fragmentary body parts of an unknown individual are found and during mass disaster. It can be assessed using dimensions of different body parts, like length of arm, forearm, hand, leg, foot etc[3, 4].

Hence, estimation of stature from fragmentary body remains has always been an area of interest for Anthropologist and Forensic experts to establish the identity of an individual[4].

Anthropometric dimensions vary among different population groups. These could be attributed to the effect of genetic and environmental factors on growth and development of an individual. Therefore need for population specific studies has long been emphasised[1, 5].

So the present study was conducted to find a relation between stature and length of arm and to formulate regression equations for estimation of stature from length of arms of adult males and females belonging to Garhwal region of Uttarakhand, India.

2. Materials and methods

A cross-sectional study was conducted in all the seven districts of Garhwal region of Uttarakhand, India. A total of 400 healthy individuals (201 males and 199 females), aged 18-40 years were selected using Stratified random sampling method.

Individuals with clinical evidence of growth disturbances, any disease condition having effect on growth of an individual, having sustained fracture or dislocation or undergone limb amputations were excluded from the study.

Prior approval of College Ethics Committee was taken for measurements made on individuals via letter no IEC/VCSGGMS&RI/46/2015 dated 15 July 2015. Informed, written, witnessed consent in vernacular of each participant was taken prior to their examination.

Measurements of individuals were taken at the place of their location.

Stature was measured using a Stature-meter, having calibrations in centimetres with accuracy of 0.1cm. The subjects were made to stand erect in anatomical position with barefoot over a flat ground with heels together and eyes directed straight ahead. Stature was measured as a distance between vertex and the inferior surface of heel and recorded in centimetres to the nearest one decimal place[6].

Length of arm was measured using a non-stretchable measuring tape, having calibrations in centimetres with accuracy of 0.1cm. The subjects were made to stand in anatomical position. The inferior border of the acromion process of scapula and superior border of the head of radius were palpated, marked and the distance between the two measured as the length of arm in centimetres to the nearest one decimal place[4].

The measurements were taken thrice and the average was taken. All the measurements were taken by the same person to avoid personal error in methodology.

Statistical analysis was done using Statistical Package for Social Sciences 17 (SPSS 17).

2.1 Statistical methods

Statistical analysis was done using Statistical Package for Social Sciences 17 (SPSS 17).

Pearson's correlation coefficient (r) was used to determine the relation, and determine its strength and type of relation between stature and length of arm. A p-value of < 0.05 was considered significant and < 0.01 highly significant.

Regression analysis was done to formulate Regression equations for estimation of stature from length of arm of both sides for total study population as well as for both males and females separately.

Coefficient of determination (R^2) was used to calculate the proportion of variance in the stature in relation to the length of arm.

Standard errors of estimate (SEE) were also calculated.

3. Results

3.1 Stature

Table 1: Stature (cm) of the study population

Sex	Number	Mean	SD	Range
Male	201	168.07	6.21	155.00-184.20
Female	199	154.60	5.71	139.00-170.30
Total	400	161.37	9.00	139.00-184.20

3.2 Length of right arm

Table 2: Length of right arm (cm) of the study population

Sex	Number	Mean	SD	Range
Male	201	31.65	1.83	26.50-37.50
Female	199	29.45	1.69	25.40-33.50
Total	400	30.56	2.07	25.40-37.50

3.3 Length of left arm

Table 3: Length of left arm (cm) of the study population

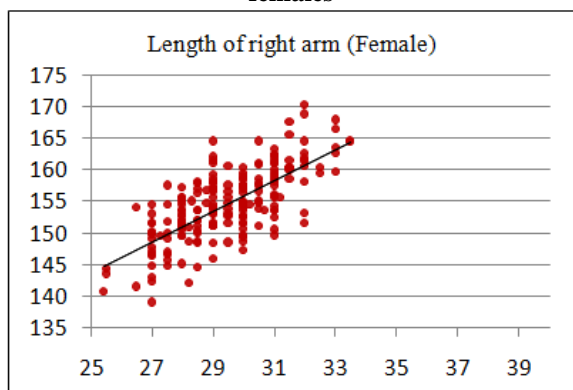| Sex	Number	Mean	SD	Range
Male	201	31.55	1.79	26.50-37.00
Female	199	29.32	1.71	25.40-33.50
Total	400	30.44	2.07	25.40-37.00

3.4 Correlation coefficient

Pearson's correlation coefficient (r) was calculated. A strong positive linear correlation was found between stature and length of arm in both males and females and it was statistically highly significant (p<0.01) (Table 4) (Graph 1-4).

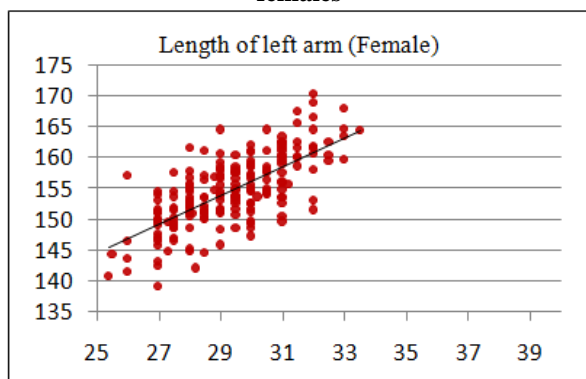**Table 4: Pearson's correlation coefficient (r) between stature and length of arm**

		Males(201)		Females(199)		Total(400)	
		RAL	LAL	RAL	LAL	RAL	LAL
Stature	**Pearson correlation**	0.698**	0.688**	0.719**	0.705**	0.795**	0.791**
	p value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

** Correlation is significant at 0.01 level (2-tailed).

Graph 1: Correlation between stature and RAL in females

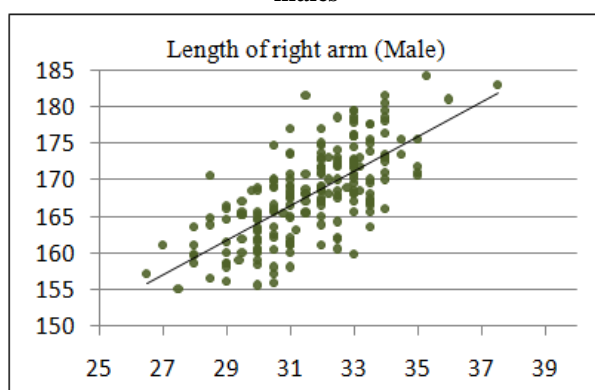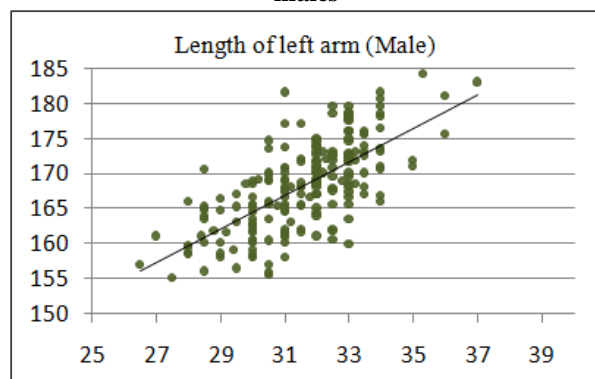**Graph 3: Correlation between stature and RAL in males**

Graph 2: Correlation between stature and LAL in females

Graph 4: Correlation between stature and LAL in males

3.5 Coefficient of determination

Coefficient of determination (R^2) was calculated as shown in Table 5.

3.6 Standard error of estimate

Standard error of estimate (SEE) was calculated. Females were found to have lower SEE values as compared to males (Table 5).

Table 5: Coefficient of determination (R^2) and Standard error of estimate (SEE)

		Males(201)		Females(199)		Total(400)	
		RAL	**LAL**	**RAL**	**LAL**	**RAL**	**LAL**
Stature	R^2	0.488	0.473	0.517	0.497	0.633	0.626
	SEE	4.46	4.52	3.98	4.06	5.46	5.51

3.7 Regression analysis

Regression analysis was done and equations formulated for estimation of stature from length of arm of both sides for total study population as well as for both males and females separately (Table 6).

Using the regression formula 'Y = A + BX ± SEE', stature can be calculated from length of arm, where Y= dependent variable (stature in cm), A= constant, B= Regression coefficient of variable, X= independent variable (length of arm in cm), SEE= Standard error of estimate.

Table 6: Regression equations for calculating stature (cm) from length of arm(cm)

		Right arm length (RAL)	Left arm length (LAL)
Stature(S)	Male	S = 92.95+2.37 x RAL±4.46	S = 92.76+2.39 x LAL±4.52
	Female	S = 82.88+2.44 x RAL±3.98	S = 85.44+2.36 x LAL±4.06
	Total	S = 55.90+3.45 x RAL±5.46	S = 56.72+3.44 x LAL±5.51

4. Discussion

Stature is an important anthropometric parameter for identification of an individual. It can be assessed using dimensions of different body parts, like length of arm. So it can be used for establishing the identity, especially when fragmentary body parts of an unknown individual are found[4,7]. These anthropometric dimensions vary among different population groups, which could be due to the effect of genetic and environmental factors on growth and development of an individual[1].

So the present study was conducted to find the relation between stature and length of arm and to formulate regression equations for estimation of stature from length of arm of adult male and female population of Garhwal region of Uttarakhand, India.

A highly significant strong positive correlation was found between stature and length of arm of both males and females. So length of arm can be used for estimation of stature and thus to establish the identity of an individual from unknown human remains. Regression equations were formulated for estimation of stature from length of arm of both sides for total study population as well as for both males and females separately. Standard error of estimate was found to be lower in females as compared to males, which could be attributed to less variation of stature and length of arm among females in comparison to males.

Similar studies were conducted by various authors in different geographic areas of the world. Nath *et al* in 1990 conducted a study on 302 females in Delhi. They correlated stature with upper arm length (UAL) and formulated a regression equation S (stature) = 82.68 + 2.29 (UAL) for estimation of stature from upper arm length[8]. Similar results are found in present study.

In another study by Nath *et al* in 1990, stature was correlated with upper arm length in 276 females aged 15-22 years in Delhi [9]. SEE was found to be 4.95, which is similar to that found in the present study.

Anand *et al* in 1991 conducted a study in Pauri-Garhwal. They found a multiplication factor of 5.59 for males and 5.89 for females for calculation of stature from upper arm length[10].

In another study conducted by Nath *et al* in 1991 on 160 male individuals aged 16-35 years in north India, stature was correlated with upper arm length[11]. SEE was found to be 5.12.

Tugcu *et al* in 2006 studied 310 adults (202 males and 108 females) in Turkey. They correlated stature with upper extremity dimensions. They found a Correlation coefficient of 0.73 and SEE of 4.75cm for length of arm in males and r of 0.74 and SEE of 4.83cm for length of arm in females[4]. The values of SEE are similar to those of the present study.

A study was conducted on 21 male and 19 female cadavers by Petrovecki *et al* in Croatia in 2007 by radiographic means. Stature was correlated with length of long bones. The Correlation coefficient between stature and length of long bones was found to be best for humerus in females[12].

In another study, stature was correlated with left upper arm length in 400 individuals (200 males and 200 females) aged 17-25 years in north India by Kaur *et al* in 2011. A strong positive correlation was found between stature and left upper arm length in males and it was highly significant. SEE was 5.621 for males and 5.326 for females[13].

Akhlaghi *et al* in 2012 studied 100 individuals (50 males and 50 females) aged 21-26 years in Iran. They correlated stature with left upper limb dimensions. A significant strong positive correlation was found between stature and length of arm[14]. This was similar to that found in the present study.

In another study conducted on 100 individuals (50 males and 50 females) aged 19-21 years by Navid *et al* in 2014, stature and upper arm length (UAL) were correlated. A strong positive correlation was found between the two, and it was statistically highly significant. This factor was a moderate predictor for stature estimation (SEE= 7.16, R^2 = 0.513). The correlation between stature and upper arm length in males was significant. However, it was a poor predictor for stature estimation (SEE = 4.52, R^2 = 0.398). Linear regression equation formulated in this study was S (stature) = 91.641+2.509 x UAL(cm) for estimation of stature from upper arm length[15]. Similar results were found in the present study.

Mumtaz *et al* in 2015 studied 150 individuals aged 18-22 years in north India. They correlated stature with right upper limb length and found a highly significant strong correlation between the two[7]. These finding are similar to those found in present study.

In another study in Gujarat in 2015, Shah *et al* evaluated 160 individuals (128 males and 32 females) aged 20-50 years. Stature was correlated with length of arm, shoulder width and foot length. Multiple regression analysis was done. SEE was found to be 6.65 and R^2 0.564. It was concluded that these were moderate predictors for stature estimation[16].

To conclude, length of arm can be used to estimate the stature of an unknown person with great accuracy and with a small standard error (SEE < 6cm). However, further studies are required using multiple body dimensions for better prediction of stature. These finding will be of help for Anthropologists and Forensic experts in estimation of stature from fragmentary body remains of an unknown individual and thus to establish the identity of

the person. It will also be of help in the field of Ergonomics and Biomedical engineering.

References

[1] Lee J-H, Jeong Y-G, Lee NS, Han SY, Han S-H. Stature estimation from partial measurements and maximum length of upper limb bones in Koreans. *International Journal of Research - Granthaalayah.* 2015;3(10):100-7.

[2] Pal DC, Datta AK. Estimation of stature from radius length in living adult Bengali males *Indian Journal of Basic and Applied Medical Research.* 2014; 3(2): 380-9.

[3] Dorjee B, Sen J. Estimation of stature from arm span, arm length and tibial length among Bengalee children aged 3-11 years. *Human Biology Review.* 2016;5(2):128-45.

[4] Tugcu H, Ozaslan A, Koc S, Ozaslan I, Tugcu H. Estimation of Stature from Upper Extremity. *Military Medicine.* 2006;171(4):288-91.

[5] Duyar I, Pelin C. Body height estimation based on tibia length in different stature groups. *American Journal of Physical Anthropology.* 2003;122:23-7.

[6] Ruparelia S, Patel S, Zalawadia A, Shah S, Patel SV. Study Of Carrying Angle And Its Correlation With Various Parameters. *NJIRM.* 2010;1(3):28-32.

[7] Mumtaz SH, Sharma BR. Estimation of Stature from Right Upper Limb Measurements. *Santosh University Journal of Health Sciences.* 2015;1(2):53-6.

[8] Nath S, Rajni, Chhibber S. Reconstruction of stature from percutaneous length of upper and lower extremity segments among Punjabi females of Delhi. *Indian Journal of Forensic Science.* 1990;4:171-81.

[9] Nath S, Krishan G. Determination of stature using percutaneous measurements of upper and lower limb bones among Hindu (Baniya) females of Delhi. *Journal of Anthropological Survey of India.* 1990;39:151-66.

[10] Anand N, Nath S. Estimation of stature through percutaneous measures of the upper and lower extremities among Rajputs of Pauri Garhwal. *Indian Journal of Forensic Sciences.* 1991;5:83-9.

[11] Nath S, Garg R, Krishan G. Estimation of stature through percutaneous measurements of upper and lower limbs among male Rajputs of Dehradun. *Journal of Indian Anthropological Society.* 1991;26:245-9.

[12] Petrivecki V, Mayer D, Slaus M, Strinovic D, Skavic J. Prediction of stature based on radiographic measurements of cadaver long bones- A study of the Croatian population. *Journal of Forensic Science.* 2007;52(3):547-52.

[13] Kaur M, Mahajan A, Khurana BS, Arora AK, Batra APS. Estimation of Stature from Upper Arm Length in North Indians – An Anthropometric Study. *Indian Journal of Fundamental and Applied Life Sciences.* 2011;1(4):151-4.

[14] Akhlaghi M, Hajibeygi M, Moradi B. Estimation of stature from upper limb anthropometry in Iranian population. *J of Forensic and Legal Medicine.* 2012;30:1-5.

[15] Navid S, Mokhtari T, Alizamir T, Arabkheradmand A, Hassanzadeh G. Determination of Stature from Upper Arm Length in Medical Students *Anatomical Sciences.* 2014;11(3):135-40.

[16] Shah T, Patel M, Nath S, Menon SK. A model for construction of height sex from shoulder width, arm length and foot length by regression method. *Journal of Forensic Science & Criminology.* 2015;2(4):402.