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Original article

RELATIONSHIP OF HAND ANTHROPOMETRY AND STATURE: AN EMPIRICAL CROSS SECTIONAL STUDY AMONG BENGALI SPEAKING HINDU POPULATION OF WEST BENGAL, INDIA

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ABSTRACT

Background: In the era of uncertainty of life and uplifment of criminal activities, there should be an enriched stock of scientific weapons for investigation and identification. In this context, prediction of stature of an individual belonging to a particular group from different body parts could enhance the procedures of identification as well as investigation.

Aim: This study was conducted to understand the relationship between hand dimensions and stature and to provide multiplication factor and regression equation for estimation of height from hand measurements.

Subjects and methods: It was conducted on 340 healthy male post graduate students (21-29 years of age) of Bengali speaking Hindu population. All anthropometric measurements were taken following standard protocol.

Results: To see the relationship between stature and hand measurements, pearson correlation coefficient was derived. Multiplication factor was derived and both simple and multiple regression analysis were used to provide regression equation separately. Mean of Height with SD is 167.25± 6.19. HLR and HLL show almost same mean with SD i.e. 18.17± 0.96 and 18.16± 0.95 respectively. HBR and HBL also show little bilateral asymmetry with mean± SD i.e. 8.22± 0.51 and 8.16± 0.51 respectively

Conclusion: All the hand measurements showed positive correlation with stature and among them hand length showed more positive correlation than hand breadth. The estimated correlation coefficient of every variable is statistically significant at the 0.01 level. Regression analysis concluded that stature estimation could be carried out from hand length more accurately within the reference population. In the present study, Simple linear regression has derived equations for all the hand parameters bilaterally for height estimation. The 'R^2' values are also showing a positive and greater regression correlation of the parameters with stature in the same line of Pearson correlation. The present study also shows multiplication factor method for height estimation from hand measurements with minimum SD and SE which means this method is also relevant on this issue.

Keywords: forensic anthropology, forensic anthropometry, stature, hand measurements, regression analysis, multiplication factor.

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INTRODUCTION

Forensic anthropometry is a scientific specialization emerged from the discipline of forensic anthropology dealing with identification of human remains with the help of metric techniques. Dismembered body parts are frequently found in modern era, due to increased events of natural disasters like earthquake, landslide etc. and man-made disasters like stampedes, building collapse, road traffic, air traffic and railway accidents, mining accidents, fire, explosions etc. Dismembered body parts are frequently found also due to increased events of the murders where the mutilation of dead body is done by a murderer to destroy all traces of identity as well as to facilitate the disposal of the dead. Forensic anthropometrist plays major role there as they provide a tentative identification of unknown remains by formulating a 'biological profile', which involves the determination of stature, sex, age and ethnicity. Among this 'big fours' of the biological profile, determination of stature is considered as one of the main parameter of personal identification in forensic examinations as it is a complex expression of genetics and environment. [Varu, 2015]

Stature is the height of the person in upright posture. It is an important physical identity. "Stature" is one of the most important elements in the identification of an individual. It is an anatomical complex that includes the dimensions of legs, pelvis, vertebral column and skull and contribution of each of these to the total varies in different individuals and also in different population. Stature is an important key feature in identification of biological profile of an individual. Hand anthropometry is found to yield important predictive information about an individual's stature and may further help in narrowing down the possible matching identities as there could be found enough hand impressions in most of the crime scenes as well as in mass disaster cases. [Moorthy and Zulkifly, 2014]

Stature can be measured by anatomical or fully method and mathematical method. Anatomical or Fully method reconstructs stature by summing the measurements of the skeletal elements that contribute to stature and adding a correction factor for the soft tissues. Mathematical method derives regression formula and multiplication factor to determine stature from bone or body part. Mathematical method is more useful in medico-legal cases as it can be applied even when only part of body is available. However, due to difference in body proportions between populations such as the relative lengths of the limbs and trunk, population-specific regression formula and multiplication factor should be used for this purpose.

Stature reconstruction is important as it provides a forensic anthropological estimation of the body height of a person in the living state – playing a vital role in identification of individual. Height estimation by measurement of various long bones has been attempted by several workers with variable degree of success. Each worker has derived his own formula for calculating the stature from long bones. However, hand measurements have not frequently been used for this. Studies on the estimation of stature from the skeletal remains or from the mutilated limbs, mostly from the long bones, have been reported as indicated by the published work of the Pearson (1899), Trotter and Glesser (1952). The Indian perspective of the problem of stature estimation has been studied by the Athwale *et al* (1963), Patel *et al.* (1964), Joshi *et al.* (1964,65), Lal and Lala (1972), Kalte and Bansal (1974), Thakur and Rai (1987), Saxena (1984), Bhatnagar *et al.* (1984), Jasuja (1987). There are also few studies in which stature is estimated from inferior extremity length and foot length Agnihotri *et al.* (2007), Ozden *et al.* (2005), Sangli *et al.* (2005), Oommen *et al.* (2005), Krishnan K. (2007), Patel *et al.* (2007).

In a study, conducted among 200 (94 males and 106 females*)* medical students of NKP Salve Institute of Medical Science and Research Centre, Nagpur, Maharashtra aged from 17 to 25 years, the correlation coefficient between hand length and stature was found to be statistically significant; for Males it showed, r= 0.699 for right side and r= 0.657 for left side, and in case of females, it showed, r=0.693 for right side and r=0.653 for left side (P = 0.001). Further, linear regression equations for determining stature were derived from both left hand and right hand of both the sexes. The efficiency of the regression equations was tested by comparing the estimated value of the stature with actual stature and a negligible difference was found. So, it was concluded that stature could be predicted in a high accuracy level using the regression equations [Wakode *et al.*2015].

In a cross-sectional study, 100 male and 100 female Malaysian Malays were included as participants, ranging from 18 to 60 years of age. According to this study the correlation coefficient of stature was found to be stronger with hand length than hand breadth and finger length measurements. Correlation coefficient values between stature and hand length were found to be more in females (0.630–0.673) than males (0.041–0.610). It also derived the linear regression equations from the stature and bilateral hand dimensions in both sexes. Standard error of estimate (SEE) of hand length was comparatively lower than hand breadth and finger lengths in both sexes. It was concluded that hand dimensions could provide good reliability in stature estimation [Moorthy and Zulkifly, 2014].

Another study was conducted on 75 male and 75 female healthy college students of Delhi aged between 18-22 years. In case of males, the study exhibited mean height of 169.0 cm with SD = ±7.8cm and mean hand length of left side of 19.5cm ±1.3cm whereas mean hand length of right side of 19.6cm ±1.3cm. In case of females mean height was found to be 158.0cm with SD = ±5.8cm and mean hand length of left side was found to be 18.1cm ±1.0cm whereas the mean hand length of right side was found to be 18.2cm ±1.0cm. According to this study there had a significant correlation between body height and hand length observed in both the sexes. No bilateral asymmetry was found. By applying the regression equations, the stature could be estimated within error of + 4.35 cm and + 4.26 cm for right and left side respectively in males while in females it is + 4.57cm and + 4.63 cm for right and left side respectively. This study concluded that the formulae derived for determination of stature from hand length could be beneficial for further use [Aggrawal*et al.* 2005].

There was another study conducted on 100 male and 100 female cadavers of more than 20 years of age randomly selected from mortuary of P. D. U. Govt. Medical College and Hospital, Rajkot during the period of December, 2012 to July, 2014. This study exhibited bilateral asymmetry in case of Hand breadth but Hand lengths did not show no bilateral asymmetry. It was found from the study that both Hand lengths as well as both Hand breadths were showing positive and significant correlation with stature but in case of Hand lengths it was being showed stronger correlation with stature than Hand breadths. It was found that regression formula and multiplication factor, both could be useful in determination of stature from Hand dimensions but regression formula could measure stature more precisely than multiplication factor [Varu *et al.*2015].

Exploring the previous studies it seems that there is scanty information on the problem under study particularly among the studied population. Thus there is need to determine the relationship of stature with hand length and hand breadth to understand the proportional relationship of this body part and to assess multiplication factor and regression equation for estimation of stature. The primary objective of the present study is to find out the correlation of hand measurements with height of an individual and to estimate the individual's height from the hand parameters under study. The other specific objectives are:

- To establish the correlation of stature with hand length and hand breadth to understand the proportional relationship of this body part that contributes in determining the total body height.
- To compute multiplication factor and regression equation for estimation of stature among Bengali speaking Hindu male students.

MATERIALS AND METHODS

A cross-sectional study was conducted on randomly selected 340 male post graduate students of West Bengal State University, North 24 Parganas, West Bengal, India. The studied students belongs to Bengali speaking Hindu population of North 24 Parganas and adjacent districts of West Bengal. The participants are within the age limit of 21-29 years as stature attains its maximum limit around 21 years. The participants are apparently healthy and free from any skeletal deformities. Thrice value of every measurement has been taken at a time and the average value of the each measurement has been taken into consideration. All the measurements have been taken on day light between 11 am and 4 pm. An informed consent has been taken from the participants before measurement.

Anthropometric measurements such as height (vertex to the standing platform), hand length (linear distance between the midpoint of a line joining the styloid process of radius and ulna bones of forearm and the tip of third finger) and hand breadth (linear distance from the most prominent point on the lateral aspect of the head of second metacarpal to the most prominent point on the medial aspect of the head of the fifth metacarpal) have been taken independently on the left and right side of each individual and recorded in centimetres. All the measurements have been recorded thrice and then their mean has been calculated for further analysis and interpretation.

Anthropometer has been used to measure vertical height for stature estimation. Martin's sliding calliper has been used for measuring both hand length and hand breadth. All the measurements have been recorded in centimetres. Data has been complied on excel sheet (MS Excel 2013) and then copied to Statistical Package for Social Sciences (SPSS 16.0). The strength of the relationships between the parameters and stature has been established by using Pearson's correlation. The regression equation and multiplication factors were derived for stature estimation.

Regression equations for stature are derived from the parameters of hand by using the formula:

$$\mathbf{Y = a + bX}$$

Where, Y = Stature, a = Value of constant, b = regression coefficient, X = parameters (of hand).

Multiplication factors for estimation stature are derived from the parameters of hand by using the formula:

Multiplication factor = Stature / parameters (of hand)

RESULT AND DISCUSSION

Since each measurement has been taken thrice for more accuracy, the trice values of each measurement of every individual have been converted into single value by estimating their average and termed as "Height"(HT), "Hand Length Right"(HLR), "Hand Length Left"(HLL), "Hand Breadth Right"(HBR), "Hand Breadth Left"(HBL).

Table: 1 shows the descriptive statistics of every anthropometric variable. Height is ranging from 145.23 to 182.40 cm. and mean of Height with SD is 167.25± 6.19 and SE is 0.33. HLR and HLL show almost same mean with SD i.e. 18.17± 0.96 and 18.16± 0.95 respectively. HBR and HBL also show little bilateral asymmetry with mean± SD i.e. 8.22± 0.51 and 8.16± 0.51 respectively.

Table: 2 exhibits Pearson correlation coefficient of every variable taken with Height. The estimated correlation coefficient of every variable is statistically significant at the 0.01 level. But the study shows that both the hand lengths have stronger correlation with stature than both the hand breadths; the ‘r’ value of HLR and HLL show 0.685 and 0.684 respectively; whereas in case of hand breadth ‘r’ value of Mean HBR and Mean HBL is 0.320 and 0.302 respectively.

Table: 3 demonstrates multiplication factor of the variables with stature with its range, mean value, SE and SD. From this mean multiplication value stature can be estimated by applying following formula: **Stature = Mean multiplication factor of the variable * value of the variable.** MFHLR ranges between 8.28 and 11.86 with SE = 0.02, MFHLL ranges between 8.29 and 11.70 with SE = 0.01, MFHBR ranges between 15.86 and 24.31 with SE = 0.06, MFHBL ranges from 15.50 to 24.37 with SE = 0.06.

Table: 4 represented regression analysis of all the foot variables as independent variables with body height as dependent variable and also contains t-value of all the foot variables. Regression analysis shows value of constant, regression coefficient and adjusted coefficient of determination. Here it is seen that adjusted R^2 showed the value trend similar to that of Pearson correlation. Foot Length Left has the maximum R^2 value of 0.414 which means it has stronger relationship than other variables as seen in case of ‘r-value’. From this table regression equations have been derived using above mentioned formula i.e. **Y=a+bX**, where Y= Body height and X= foot anthropometry (hand length or hand breadth). So the estimated regression equations through simple regression analysis are:

1. **Y (Height) = 87.010+4.414*HLR**
2. **Y (Height) = 135.693+3.836*HBR**
3. **Y (Height) = 86.804+4.429*HLL**
4. **Y (Height) = 137.447+3.653*HBL**

All the figures (Fig1-Fig-4) contain scatter diagram of all the hand variables with body height like HLR, HLL, HBR and HBL respectively.

Table: 5 reveals multiple regression coefficients of body height as dependent variables with taken hand variables as independent variables which are formed to show multiple effect of length and breadth of a hand together on body height and to estimate the regression equation of height from hand length and hand breadth together. The equation is, **Y (Height) =** $\mathbf{a+b_1X_1+b_2X_2}$, where b_1= b-value of length and b_2= b-value of breadth, on the other side X_1= hand length and X_2= hand breadth. And the estimated regression equations through multiple regression analysis are:

1. **Y (Height) = 83.710 +(4.258*HLR)+(0.746*FBR)** (from right hand)

2. **Y (Height) = 83.024 +(4.276*HLL)+(0.803*FBL)** (from left hand)

CONCLUSION

Estimation of stature from anthropometric measurements is an area of interest for forensic experts for the purpose of identification. The data derived from entirely different population cannot be used for height assessment for all types of population hence the baseline data shall be derived from local population so that they can be used for the height assessment amongst them.

The present study shows a good statistically significant correlation of all the hand measurements with stature but both the hand length show higher correlation with stature than other hand variables. Similarly, a positive significant correlation was found between stature and hand length in a particular population in this study (P= 0.001). Simple linear regression has derived equations for all the hand parameters bilaterally for height estimation. The 'R^2' values are also showing a positive and greater regression correlation of the parameters with stature in the same line of Pearson correlation. The present study also shows multiplication factor method for height estimation from hand measurements with minimum SD and SE which means this method is also relevant on this issue.

It was concluded that the estimation of stature among the Bengali speaking Hindu population can be carried out using hand length more accurately and there are positive and higher correlation between stature and hand length than hand breadth in the reference population.

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Table: 1-Descriptive Statistics of all the variables

Variables	N	Minimum	Maximum	Mean	Std. Error	Std. Deviation
Age (in year)	340	21	29	22.94	0.11	2.06
HT (in cm)	340	145.23	182.40	167.25	0.33	6.19
HLR (in cm)	340	14.03	21.07	18.17	0.05	0.96
HLL (in cm)	340	14.13	21.00	18.16	0.05	0.95
HBR (in cm)	340	6.93	10.20	8.22	0.02	0.51
HBL (in cm)	340	7.00	10.30	8.16	0.02	0.51

"Height"(HT), "Hand Length Right"(HLR), "Hand Length Left"(HLL), "Hand Breadth Right"(HBR), "Hand Breadth Left"(HBL)

Table: 2-Correlation of body height with hand length and hand breadth

Hand variables	HT
HLR	0.685**
HLL	0.684**
HBR	0.320**
HBL	0.302**

** Significant, $p<0.01$

"Hand Length Right"(HLR), "Hand Length Left"(HLL), "Hand Breadth Right"(HBR), "Hand Breadth Left"(HBL)

Table: 3-Multiplication Factor of hand parameters with stature

	N	Minimum	Maximum	Mean MF	Std. Error	Std. Deviation
MFHLR	340	8.28	11.86	9.21	0.02	0.36
MFHLL	340	8.29	11.70	9.22	0.01	0.36
MFHBR	340	15.86	24.31	20.38	0.06	1.22
MFHBL	340	15.50	24.37	20.55	0.06	1.24

**** Multiplication Factor = stature / parameter**

Table: 4- Regression coefficient between body height as dependent and hand anthropometry as independent variables

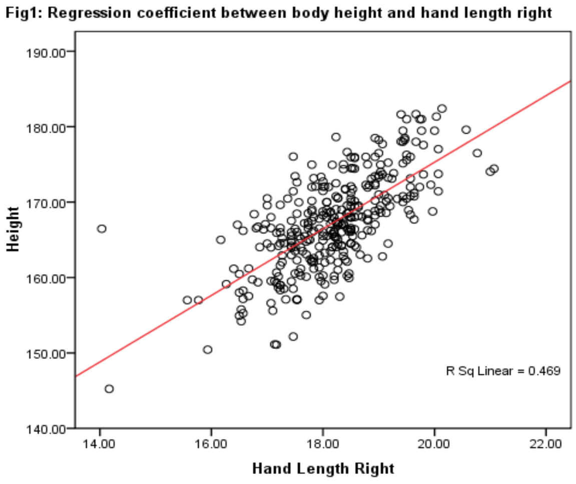
Independent variables	Constant (a)	b-value	Adjusted R^2	t-value	p-value
HLR	87.010	4.414	0.468	17.286	0.001
HLL	86.804	4.429	0.467	17.261	0.001
HBR	135.693	3.836	0.100	6.203	0.001
HBL	137.447	3.653	0.088	5.817	0.001

Where, R^2 = coefficient of determination, b = regression coefficient, a = value of constant.

“Hand Length Right”(HLR), “Hand Length Left”(HLL), “Hand Breadth Right”(HBR), “Hand Breadth Left”(HBL)

Table: 5-Multiple regression coefficient of body height as dependent with length and breadth of hand as independent variables

Independent variables	Constant (a)	b-value		Adjusted R^2
		Length	Breadth	
Right hand	83.710	4.258	0.746	0.469
Left hand	83.024	4.276	0.803	0.469



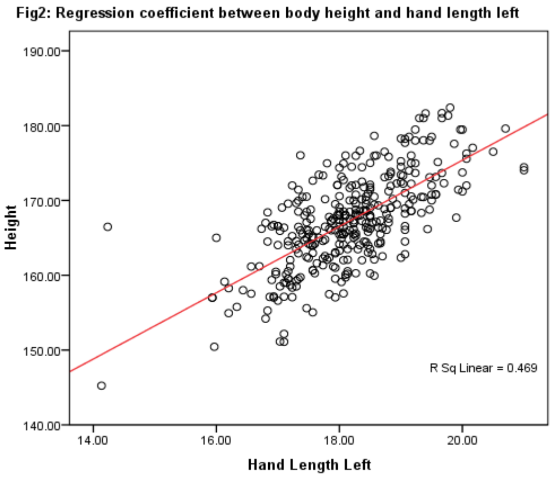


Fig3: Regression coefficient between body height and hand breadth right

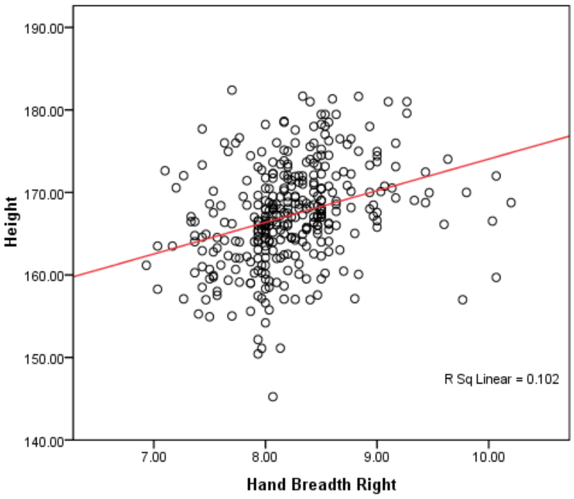


Fig4: regression coefficient between body height and hand breadth left