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A Study Based on Somatometric Measurements of Hand and Foot for the Estimation of Stature of Ramgarhia Sikh Population in Delhi Region

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Abstract

In forensic investigation difficulties are being experienced in the stature and gender estimation of bodies dismembered in mass destruction and criminal mutilation.

The study is based on a sample of 175 subjects (85 males and 90 females) of "Ramgarhia Sikh Population" from Delhi, aged between 20 and 50 years. Four Somatometric measurements: Hand Length, Hand Breadth, Foot Length and Foot Breadth taken on the right side in each subject were included in this study.

Stature was measured using standard anthropometric techniques. Sex differences were found to be highly significant for all the measurements ($P<0.01$). Linear and multiple regression equations for stature estimation were calculated using the above mentioned variables. The correlation coefficients between stature and all the measurements of hands and feet were found to be positive and statistically significant [1].The highest correlation in males was found to be in between stature and foot length, whereas in the females the highest correlation was between stature and hand length, providing reliability and accuracy of these body parts for the estimation of stature.

Keywords: Forensic Anthropology; Stature; Anthropometry; Somatometry; Ramgarhia Sikh.

Introduction

Forensic Anthropometry helps in reconstruction of the biological profile of the person (alive or dead) such as age, sex, ethnicity and stature.Among these 'big four' of forensic anthropology, estimation of stature is considered as one of the main parameter of personal identification in forensic examinations. Stature provides insight into various features of a population including nutrition, health and genetics. It is an inherent characteristic; its estimate is considered to be an important assessment in the identification of unknown human remains [2].

With the increasing frequency of mass disasters, homicides, air plane crashes, train and road accidents etc., there is always need for measuring body parts which help in identifying the deceased from fragmentary and dismembered human remains. It is very common to find the peripheral parts of the body such as hand and foot in such disasters. Hand and foot remain intact and thus in such a situation, their anthropometric measurements provide good approximation about the height of a person [3].

Stature is determined by measuring overall length of long bones and applying formulae that are based on the relatively constant R / S of each bone length to stature. Stature of intact body is obtained by direct measurement in supine position. Stature estimation is performed only after identifying age, sex and race. As a rule of thumb, the larger the skeletal element, the taller theindividual[4][5].

Materials Used

Verificator (Gauze; 10-250mm) was used for calibration of instruments. Anthropometric Rod (200cm) was used to measure the stature of an individual. Rod Compass was used to measure the Foot length of an individual, whereas the Sliding Caliper (25cm) was used to measure the Hand Length, Hand Breadth and Foot Breadth of an individual ; SPSS V22 Software.

Methodology

The present study is based on estimating stature from the measurements of hand and foot in the Ramgarhia Sikh Population of Delhi.Ramgarhia's are one of the major endogamous caste groups of North India, a large number of them living in Punjab and Delhi. Ramgarhia is associated mainly with the Tarkhan Tribe. They are primarily expert carpenters and blacksmiths[6].

This study includes Ramgarhia's residing in Delhi region of North India. The range of age for the study is 20 to 50 years. Parameters taken are: Hand-Length, Hand-Breadth, Foot-Length, Foot-Breadth, and Stature on the right side of each individual.All the measurements were taken scientifically. Before taking the Somatometric measurements, each subject was asked to remove the shoes. The subjects were healthy and free from any apparent symptomatic deformity. The data were subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) and regression formulae were calculated for various combinations to reach the best estimate possible [7].

Landmarks And Techniques Involved In Taking Somatometric Measurements[4]

Height (Stature)

It is the vertical distance between the point vertex and the floor.

Vertex: It is the highest point on the head when head is held in F.H. (Frankfurt Horizontal) plane.

- The subject was instructed to stand on the plane floor and to stand erect so that his / her heels and buttocks, back touch to the wall. The hands turned inwards and fingers pointing downwards.
- Then the subjects head was brought to Frankfurt plane and asked to take deep breath.
- And then total height was measured from the right side of the subject with anthropometer in the median sagittal plane of the subject by moving cross bar to touch the vertex up to the floor level.

Hand Length (HL): It measures the straight distance between the mid-point of a line joining the two stylion (sty) and dactylion (da) of the middle finger.

- The subject was instructed to place his / her hand straight and stretched with palmer side up on a flat surface.Then measures the straight distance between the first crease and the tip of middle finger.

*Hand Breadth (HB):*It measures the straight distance between metacarpal radiale (mr) and metacarpal ulnare (mu).

- The subject was instructed to place his / her hand stretched to its maximum on the table. The fingers should be together and on line with forearm.

Foot Length (FL): It measures the straight distance directly from pternion(pte) to acropodion (ap) when the foot is stretched.

- While subject was standing the fixed arm of the rod compass was adjusted back to the foot slightly and movable arm was touched to the foremost point of the toe I or II.

Foot Breadth (FB): It measures the straight distance between metatarsal tibiale (mtt) and metatarsal fibulare (mtf) when the foot is stretched.

- Subject was instructed to stand straight and then with the sliding caliper breadth of the foot was measured horizontally by adjusting the moving sliding sleeve.

Statistical Analyses [8]

The data obtained were computed and analyzed with SPSS (Statistical Package for Social Sciences, version 22.0) computer software. Multiplication factor for stature estimation was derived by dividing stature by hand and foot dimension in each individual.Mean of multiplication factor derived in each individual was taken as the multiplication factor for the study group. Male-female differences in the stature, hand and feet measurements and for the derived multiplication factors for estimation of stature were compared using Student's t-test. Level of significancewas set at p-value less than 0.05. Regression formulae were derived for stature estimation from hand (HL, HB) and foot dimensions (FL, FB) in males and females, keeping stature as the dependent and each hand or foot dimension as an independent variable. Multiplication factors and regression equation thus derived for each variable were applied in the study group itself and the stature

was estimated [9]. Actual stature and the estimated stature frommultiplication factor method as well as from regression analysis method were compared and the error of estimate was calculated by finding the difference between estimated and the actual stature (Error of Estimate = Estimated stature - Actual stature)[10].

Result and Discussion

Table 1: Descriptive Statistics of Various Body Demensions for Males and Females

S.No.	Variables	Males (N=85)			Females (N=90)		
		Mean(Cms)	Sd*(Cms)	S.E.**(Cms)	Mean(Cms)	Sd*(Cms)	S.E.**(Cms)
1	Stature (S)	167.54	7.6	0.82	154.17	5.5	0.58
2	Hl	18.68	1.03	0.11	17.23	0.78	0.08
3	Hb	8.46	0.44	0.04	7.65	0.38	0.04
4	Fl	25.61	1.3	0.14	23.21	1.0	0.11
5	Fb	9.78	0.7	0.07	8.88	0.5	0.05

*SD -.Standard deviation (σ) is the positive square root of the average of squared deviation taken from arithmetic mean.
S.E - Standard error of mean, **S.E.M = $\sigma/\sqrt{n}$, where S.E.M = Standard Error of Mean
σ = standard deviation; n = number of samples

Table 1 shows descriptive statistics for stature and measurements of hands and feet in both the genders. Mean value, standard deviation, and standard error of mean in stature, hand length, hand breadth, foot length and foot breadth on right side are presented. The values of all the measurements in case of males are higher than in females. Here it is clear that males are having larger dimensions on all the above mentioned variables in comparison to females.

Table 2: Correlations of Stature with Different Body Dimensions among Male and Female

S.No	Variables	Value of Correlation In Female	Value of Correlation in Male
1	Hl	0.591**	0.593**
2	Hb	0.384**	0.366**
3	Fl	0.444**	0.699**
4	Fb	0.168	0.360*

*significant (p-value: 0.01<p<0.5). Correlation is significant at 0.05 levels.
**strongly significant (p-value: p=<0.01). Correlation is significant at 0.01 levels.

Table 2 shows correlation between stature and different body dimensions in males and females. The highest correlation is of foot length and stature in case of males whereas the maximum correlation of stature is with the hand length in case of females. The lowest correlation with stature is seen with foot breadth in both the males and females.

Table 3: Linear Regressions for Estimation of Stature for Males and Females from Different Body Dimension

Males (N=85)	Females (N=90)
S = 85.73+4.38(Hl)	S = 81.7+4.21(Hl)
S = 123.06+5.27(Hb)	S = 111.19+5.61(Hb)
S = 63.31+4.07(Fl)	S = 100.67+2.31(Fl)
S = 130+3.85(Fb)	S = 138+1.84(Fb)

Here, 'S' stands for'Stature'

Table 3 lists the regression equations for estimation of stature from measurements of hands and feet in both the sexes. Worldwide, the regression formulae are accepted as of utmost importance in determination of stature from various Somatometric dimensions. Regression equations have been computed separately, for each sex, and for each measurement of the hand and foot.

Table 4: Differences in Actual and Estimated Stature Using Regression Equation for Hand and Foot Dimensions among Maleand Female

DIMENSIONS	Males (N=85)			Females (N=90)		
	Estimated Stature (Cm)	Actual Stature (Cm)	Error [SEE]*(Cm)	Estimated Stature (Cm)	Actual Stature (Cm)	Error [SEE]*(Cm)
HL	167.54	167.54	0.00	154.18	154.17	0.01
HB	167.59	167.54	0.05	154.10	154.17	0.07
FL	167.54	167.54	0.00	154.28	154.17	0.11
FB	167.65	167.54	0.11	154.33	154.17	0.16

*Standard Error of Estimate (SEE)

Table 4presents multiple regression equations for the estimation of stature from different combinations of the dimensions of hands and feet in both the sexes. It is observed that the linear regression equations reveal lower values of SEE (i.e. 0 to 0.11 in males and0.01 to 0.16 in females) than the values given by linear regression equations.

Table 5: Differences in Actual and Estimated Stature Using Multiplication Factor (M.F.) and Regression Equation For Hand and Foot Dimensions Among Maleand Female.

DIMENSIONS	Males (n=85)			Females (n=90)		
	Estimated Stature (cm)	Actual Stature (cm)	Error [SEE]** (cm)	Estimated Stature (cm)	Actual Stature (cm)	Error [SEE]**(cm)
HL	167.54	167.54	0.20	154.20	154.17	0.03
HB	167.76	167.54	0.22	154.45	154.17	0.28
FL	167.48	167.54	-0.06	154.34	154.17	0.17
FB	168.0	167.54	0.46	152.2	154.17	-1.97

**Standard Error of Estimate (SEE)

Table 5 presents multiplication factor for the estimation of stature from dimensions of hands and feet in both the sexes. It is observed that the multiple regression equations reveal higher values of SEE (i.e. -0.06 to 0.46 in males and -1.97 to 0.28 in females) than the values given by linear regression equations.

Table 6: Summarises the Work Done by Various Authors on Hand Length Compared to Present Study [11][12]

Author	Parameters	Males	Females
Sunil, Dikshit, Aggarwal And Rani, 150 (75 Males And 75 Females) Of Delhi	Regression Equation	S = 85.84+ 4.32 (Hl)	S = 80.94+ 4.40 (Hl)
Nath, Rajni And Chhibber, 302 Punjabi Females Of Delhi	Multiplication Factor Regression Equation	-	9.12 S = 85.22+ 4.05 (Hl)
Sethi And Nath, 204 Punjabi Females Of Delhi	Regression Equation	-	S = 88.04+ 2.95 (Hl)
Manpreetkaur Et Al 400 (200 Males And 200 Females) Of North India	Regression Equation	S = 130.90 + 2.398 (Hl)	S = 160.41 + 0.027 (Hl)
Present Study (85 Males And 90 Females) Of Ramgarhia Sikh Population Of Delhi.	Multiplication Factor Regression Equation	8.98 S =85.73+4.38(Hl)	8.95 S = 81.7+4.21 (Hl)

Table 6,7&8, Multiplication factor for stature estimation was derived by dividing stature by hand and foot dimension in each individual. M.F. = Stature/Body Dimension

Table 7: Multiplication Factor (Mf) for Foot Length Measurement Among Different Indian Population [13][14]

S.No	Population/ Region	Author / Year	M.F.
1	Rajput (F) / Garhwal, U.K	Anand & Nath (1990)	7.13
2	Rajput (M) / Garwahl, U.K	Anand & Nath (1990)	6.42
3	Rajput (F) / Garhwal, Sirmour	Kaur (1996)	6.71
4	Rajput (M) / Garhwal, Sirmour	Kaur (1996)	6.57
5	Jat (F) / Churu, Rajasthan	Nath & Rautray (1996)	6.68
6	Jat (M) / Churu, Rajasthan	Nath & Rautray (1996)	6.60
7	Sikh (F) / Delhi	Kaur (1998)	6.79
8	Sikh (M) / Delhi	Kaur (1998)	6.60
9	Sikh (F) / Delhi	Present Study (2015)	6.65
10	Sikh (M) / Delhi	Present Study (2015)	6.54

Table 8: Multiplication Factor for Foot Breadth Measurements among Different Indian Population [13][14]

Sno	Population/ Region	Author/Year	M.F.
1	Shia Muslims (M)/Delhi	Bhavana & Nath (2008)	16.62
2	Sikh(M)/Delhi	Present Study (2015)	17.18
3	Sikh(F)/Delhi	Present Study (2015)	17.41

Conclusion

Population variations in Somatometric dimensions do exist and are attributed to genetic, dietary habits and environmental factors. This indicates that specific formulae or regression equations used in prediction of stature are only applicable to the population from which the data were collected [15].

By analyzing the data collected for various body dimensions for Sikh population of Delhi following conclusion can be furnished:

- The average stature of females (154.17 cm) is less than that of males (167.54 cm).
- Dimensions like HL, HB, FL, and FB as expected were showing lesser values for females as compared to males.
- Multiplication factor for all the four body dimensions for both males and females were uniform, showing very less variation when compared to their counter parts for opposite sex. Maximum variation in multiplication factor between males and females is seen in the case of HB and minimum variationin multiplication fact or between males and females is shown in case of HL.
- Regression equations for all the four body dimensions to calculate the stature were formulated. Zero error value was found while computing the stature from regression equation for both the sexes. So, it can be concluded that the HL is the best suited body dimension for estimation of staturein females and FL is the best suited body dimension for stature estimation in Sikh population of Delhi.
- Sex differences were found to be highly significant for all the measurements ($P < 0.01$). [11] Linear regression equations for stature estimation were calculated using the above mentioned variables. The correlation coefficients between stature and all the measurements of hands and feet were found to be positive and statistically significant.
- The highest correlation coefficient between stature and foot length in males indicate that the foot length provides highest reliability and accuracy in estimating stature of an unknown male, whereas, in females, the highest correlation was found between hand length and stature indicating that the hand length provides highest reliability and accuracy in estimating stature of an unknown female.

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