Original Article

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Stature Prediction & Anthropometric Hand Dimensions: A Relationship Unearthed

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Abstract

One of the most vital and useful anthropometric parameter that determine the physical identity of a human is stature or body height. Height Estimation of an individual is important not only for anthropologists and forensic medicine personnel but also for physical assessment of status of nutrition in an individual by nutritionists and physicians. Prediction of stature from incomplete and decomposing skeletal remains is one of most demanding criteria in establishing the identity of an unknown individual. It is a useful tool in medico legal and forensic examination. *Study Design*: Descriptive cross sectional study. *Place of Study*: Department of Anatomy, MGM medical college, Aurangabad. *Material*: 185 young and healthy college students aged between 18 to 24 years having no disease or deformity were examined anthropometrically in respect to their height and length of right and left hand. *Method*: After applying exclusion criteria proper selection of subjects were made. Measurement of height, hand length, hand breadth, and middle finger length of right and left side was taken with a standard anthropometer and a vernier callipers using standard reference points for measurements. *Result*: The present study showed there exists a significant sexual dimorphism in male and female population. Males have higher values than the females in dimensions of hand and foot. The correlation of stature and middle finger length is on the higher side (p= 0.00). In fragmented bodies, the multivariate regression formulas used to calculate the stature from the hand dimensions in both sexes gives a better prediction of stature than the univariate type.

Keywords: Anthropometric Measurement; Skeletal Remains; Height; Stature; Hand-Length; Hand-Width.

Introduction

Since many years, the dimensional relationship between body segments and stature has been the interest of artists, scientists, anatomists, anthropologists and medico legalists [1]. It also helps in ergonomics like designing of machines and fashion designing.

Establishing the identity of an individual has become an important need in mutilated, decomposed, & amputated body fragments in recent times due to natural disasters like earthquakes, tsunamis, cyclones, floods and man-made disasters like terror attacks, bomb blasts, mass accidents, wars, plane crashes etc. The determination of stature is an important step in the identification of dismembered remains [2]. So, estimation of stature from extremities and their parts plays an important role in identifying the dead in forensic examinations in establishing personal identification of the victims [3]. The body parts show biological correlation with stature. Evaluation of various anthropological parameters with proportions plays a role in sports medicine, designing of instruments and education. Height of an individual is affected by diverse factors such as race, gender and nutrition. The height achieved by the individuals is also under the control of genes and environment. The body size such as height and weight can be assessed by growth, nutritional status, body surface area and pulmonary function of children [4,5]. In human evolution, one of man's greatest achievements over a long period of time is upright posture. Natural height or stature of a person is

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usually taken in upright position. The hand dimensions can be used as a basis for estimating stature related to age [6-8].

Aim

Sexual dimorphism study and correlation between various dimensions of hand and stature, in 18-24 age groups.

Objectives

1. To obtain dimensions of hands (i.e. hand length, hand breadth, middle finger length) and stature of Medical students in age group 18-24 years in MGM Medical College, Aurangabad, with documentation of gender.
2. To find out the correlation between dimensions of hands with the stature of the individual.
3. To devise linear univariate and multiple regression formulae to estimate stature from these dimensions

Materials and Methods

Method of Collection of Data

The study was done after necessary permissions from authorities and written consent from subjects. Measurements were taken of 185 students consisting of 81 males and 104 females in the age group of 18-24 years studying in MGM Medical College, Aurangabad.

Measurements of male and female adult subjects were taken by selecting them as below:

Inclusion Criteria

1. Healthy and normal adult subjects of age group 18-24 years.

Exclusion Criteria

1. Subjects with musculoskeletal deformity like kyphosis, scoliosis, poliomyelitis, trauma etc, hormonal disorders like gigantism, dwarfism, etc and genetic disorders like turners syndrome, etc which will affect the normal measurements of stature and hand dimensions.

The following instruments were used to carry out this study:

1. Anthropometer (Stadiometer).
2. Vernier (Sliding) calipers (digital type).
3. Steel tape.

Method of Measurements [9,10]

Stature

It is measured as vertical distance from vertex (the highest point on the top of head) to the floor in mid-saggital plane with subject standing barefooted, on an even floor and the head being oriented in the Frankfurt's plane. Stature was measured with the help of Stadiometer (Anthropometer).

Hand Length

It is the straight distance from mid-point of a line connecting the styloid processes of radius and ulna to the anterior-most projection of the skin of the middle

Fig. 1:

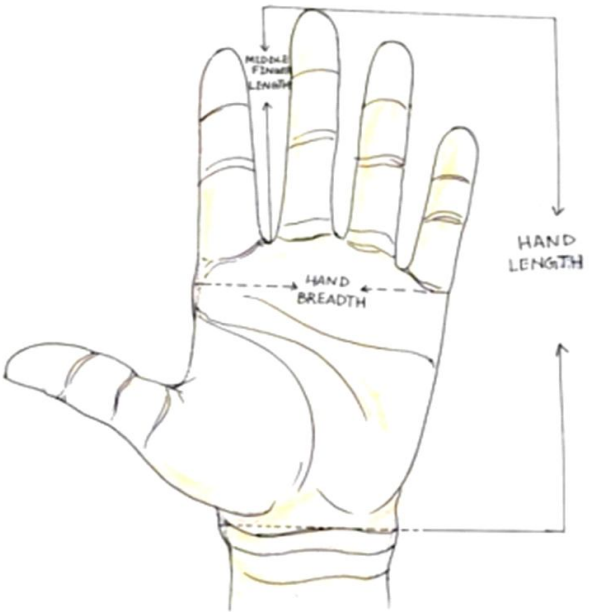

Fig. 2:

finger. It was measured with the help of Digital Vernier calipers. The hand is laid flat on a table.

Hand Breadth

It is the distance between the most prominent point on the lateral side of head of second metacarpal and the most prominent point on the medial aspect of the head of fifth metacarpal. It was measured with the help of Digital Vernier calipers.

Total Length of Middle Finger

It is measured from the proximal flexion crease at the base of the middle finger to tip of the middle finger. The wrist is neutral in position and hand is fully extended. The measurement is taken on the palmer aspect of the hand. It was measured with the help of Steel tape.

These measurements were taken from both the hands of the body. Male and female readings for each parameter were separated and analyzed. All the measurements were taken in a reasonably well lit room, at a fixed time between 3:00 p.m. and 5.30 p.m. to eliminate diurnal variation. It was measured and recorded only by one person, to avoid inter observer error in methodology. All the measurements were recorded thrice and then their mean was calculated for accuracy.

The height, hand length, hand breadth and middle finger length of subjects were used to assess the relationship between the hand dimensions and stature. For all parameters, analysis was done by calculating Mean, STD error of mean, STD deviation, Maximum, Minimum separately, Skewness and Kurtosis.

Then correlation and coefficients between these anthropometric measurements were calculated. The regression equations of stature as dependable variable were fitted with hand dimensions as independent variables. And effectiveness of these regression equations was tested. For every parameter, Stature (Height) was considered to be independent and correlation was checked between the height and other parameters. Later on univariate and multivariate regression formulas were derived for each parameter. The data were subjected to statistical analysis using statistical package for social sciences (SPSS).

Observation

The following things were observed as shown in table 1 below:

It is seen from above table no.1 that values here are showing negatively skewed distribution in males and positively skewed distribution in females. It also shows platykurtic distribution.

Table 2: One way ANOVA shows F value as 170.143 with 0.00 significance suggesting statistically significant difference in male and female height as shown in table 1.

Table 1: Height (in Centimeters)

	Male	Female
Mean	171.116	157.578
Std. Error of mean	0.843	0.637
Std.deviation	7.684	6.348
Maximum	188	175
Minimum	147	141
Skewness	-0.283	0.228
Kartosis	0.660	-0.090

Table 2:

One way ANOVA			Sum of Squares	DF	Mean Square	F	Sig.
Ht (cm)	Between Groups	(Combined)	8561.364	1	8561.364	170.143	0.000

Table 3: Hand Length (in Centimeters)

	Male		Female	
	Right	Left	Right	Left
Mean	18.607	18.631	16.922	16.851
Std. Error of mean	0.081	0.084	0.082	0.079
Std.deviation	0.744	0.769	0.857	0.829
Maximum	20.4	20.4	19.9	19.3
Minimum	17.3	17.3	15.3	15.2
Skewness	0.617	0.460	0.555	0.456
Kartosis	-0.436	-0.503	0.540	-0.020

It is observed from above Table 3 that the hand length is showing positively skewed distribution of values in both males and females. Kurtosis shows platykurtic distribution.

One way ANOVA shows F value as 197.140 and having significance of 0.0, suggesting statistically significant difference in male and female hand.

It is seen from above Table 5 the mean hand breadth of males is more than females with standard error of mean being 0.054 cms in males and 0.04 cms in females. Hand length is showing positively skewed distribution of values in both males and females except a minute negatively skewed right side in males. It also shows platykurtic distribution.

One way ANOVA shows F value as 221.050 with 0.00 significance, suggesting statistically significant difference in male and female hand breadth.

Table 8

Table 4:

	One way ANOVA		Sum of Squares	DF	Mean Square	F	Sig.
HL (cm)	Between Groups	(Combined)	129.375	1	129.375	197.140	0.000

Table 5: Hand Breadth (in Centimeters)

	Male		Female	
	Right	Left	Right	Left
Mean	8.741	8.658	7.707	7.555
Std. Error of mean	0.0538	0.054	0.0422	0.038
Std.deviation	0.479	0.491	0.441	0.397
Maximum	10	9.9	9	8.5
Minimum	7.79	7.6	6.9	6.7
Skewness	-0.084	0.363	0.201	0.070
Kartosis	-0.335	-0.199	0.182	0.329

Table 6:

	One way ANOVA		Sum of Squares	DF	Mean Square	F	Sig.
HB (cms)	Between Groups	(Combined)	47.125	1	47.125	221.050	0.000

Table 7: Middle Finger Length (in Centimeters)

	Right	Left	Right	Left
Mean	8.171	8.185	7.310	7.282
Std. Error of mean	0.043	0.043	0.044	0.042
Std.deviation	0.398	0.393	0.462	0.447
Maximum	9	9	8.5	8.4
Minimum	7.3	7.3	6.2	6.2
Skewness	-0.052	-0.071	0.308	0.187
Kartosis	-0.613	-0.582	0.296	-0.048

Table 8:

	One way Anova		Sum of Squares	DF	Mean Square	F	Sig.
MFL (cm)	Between Groups	(Combined)	34.505	1	34.505	181.737	0.000

Mean middle finger length is observed of males is 8.17 cms and that of female is 7.3 cms indicates that the mean middle finger length of males is more than the females with a standard error of mean in males being 0.043 and females is 0.04.

The values are slightly negatively skewed in males and positively skewed in females. Values show platykurtic distribution.

One way ANOVA shows F value as 181.737 with 0.000 significance suggesting statistically significant difference in male and female middle finger length.

Following regression formulae has been derived using SPSS of one variable and multi-variables. They are as follows:

Univariate Analysis

1. Hand Length (Equ.Uni-1)

   R Value = 0.765

F Value = 266.126

Height = 49.398 + [6.458 * (Right Hand length)]

2. Hand Breadth (Equ.Uni-2)

R Value = 0.644

F Value = 134.256

Height = 87.885 + [9.266 * (Right Hand breadth)]

3. Middle Finger Length (Equ.Uni-3)

R Value = 0.720

F Value = 203.966

Height = 74.651 + [11.544 * (Right Middle finger length)]

Multivariate Analysis

1. Height versus Right Hand length and Right Hand breadth. (Eqution. Muti-1)

R Value = 0.772

ANOVA is significant

Height = 48.524 + [5.428 * (Right Hand length)] + [2.340 * (Right Hand breadth)]

2. Height versus Left Hand length and Left Hand breadth. . (Equation. Muti-2)

R Value = 0.778

ANOVA is significant

Height = 52.013 + [5.1 * (Left Hand length)] + [2.678 * (Left Hand breadth)]

3. Height versus Right Hand length, Right Hand breadth, Left Hand length and Left Hand breadth.. (Equation. Muti-3)

R Value = 0.783

ANOVA is significant

Height = 50.037 + [3.186 * (Right Hand length)] + [2.049 * (Left Hand length)] – [1.567 * (Right Hand breadth)] + [4.207 * (Left Hand breadth)]

4. Height versus Right Hand length, Right Hand breadth, Left Hand length, Left Hand breadth, Right Middle finger length and Left Middle finger length .(Equation. Muti-4)

R Value = 0.784

ANOVA is significant

Height = 51.285 + [2.847 * (Right Hand length)] + [1.635 * (Left Hand length)] – [1.566 * (Right Hand breadth)] + [3.873 * (Left Hand breadth)] + [0.345 * (Right Middle finger length)] + [1.571 * (Left Middle finger length)]

Discussion

One of the earliest to use such anthropological rules for stature prediction was ancient Egyptians (Richer and Hale, 1971). Studies by Pearson (1899), Trotter and Glesser (1952) [11,12] have reported on the prediction of stature from skeletal remains or mutilated limbs, mostly from long bones.

On the Indian side, Athwale et al (1963), Patel et al (1964), Joshi et al (1964, 65), and Jasuja et al (1991, 1993, 1997) [13-17], also studied stature estimation by significant dimensional relationship of length of foot, hand, hand with forearm, arm, upper extremity, length of head, height of head etc. Crown to rump and rump to heel ratio etc and found that there exists significant correlation between body segments and height.

There also exist population variations in anthropometric dimensions. Stature is partly determined by length of bones in upper limb and lower limb. It is also influenced by many other factors such as genetics, environment, gender, age and physical activity [18]. Also, till the ossification being complete and skeletal maturity attained by the age of 25 years, the rate or growth in males and females varies during the course of development.

All parameters show significant sexual dimorphism in this present study. There was a strong positive correlation between hand measurements (hand length, hand breadth and middle finger length) and stature ($p < 0.01$), which was highest for middle finger length. Hence these can be successfully used for estimation of stature. Anatomists, archaeologists, anthropologists, design engineers and forensic scientists can now predict height of an individual more accurately by the regression equations derived in this study. The only precaution to be taken into consideration is that these formulae are applicable to the Indian region population from which the data has been collected. It is due to the inherent population variation in these dimensions, which may be attributed to genetic, lifestyle differences and environmental factors like nutrition, climate etc [19].

Thus, in males and females, middle finger length is the best parameter for estimation of stature. The relatively low standard estimate of standard error of mean for the middle finger length in males (±0.043) and for middle finger length in females (± 0.042) ensures better accuracy in stature estimation.

The presence of a positive linearity between the anthropometric parameters and estimation of stature facilitates formulation of regression equations which can be successfully utilized for stature estimation in

Indian population. In the present study, males showed higher mean values in all parameters studied when compared with mean values of female parameters.

Studies done to estimate stature by Kaur [23] and OP Jasuja [6] has reported significant higher mean values for males amongst Indians, and both their study groups were from North India. Danborno B

Table 9: Stature

S. No	Name of the author	Sex	Min. Stature	Max. Stature	Mean	± SD	± SE
1.	Thakur[19] (1975)	-	-	-	167.4	6.4	-
2.	Jasuja[6] (2004)	Male	166.2	185.6	175.2	5.24	0.957
		Female	152	167.9	159.7	5.17	0.945
3.	Patel[19] (2007)	Male	-	-	170.96	5.13	-
		Female	-	-	156.14	5.15	-
4.	Danborno B[20] (2008)	Male	-	-	173.73	7.13	-
		Female	-	-	160	6.22	-
5.	Ilayperuma[21] (2009)	Male	-	-	170.14	5.22	-
		Female	-	-	157.55	5.75	-
6.	Rahul[22] (2013)	Male	157	192	169.97	5.71	
		Female	139	167	154.2	7.15	
7.	Kaur et al[23] (2013)	Male	-	-	175.98	6.76	-
		Female	-	-	160.91	5.75	-
8.	Srivastava[24] (2014)	Male	-	-	170.9	-	0.371
		Female	-	-	156.21	-	0.49
9.	Present Study (2014)	Male	147	188	171.11	7.68	0.84
		Female	141	175	157.57	6.34	0.63

Table 10: Middle Finger Length

S. No	Authors	Measurements	Sex	Side	Min	Max	Mean	± SD	± SE
1	Rahul[22] (2013)	Middle Finger Length	Male	-	7.1	9.5	7.92	0.420	-
			Female	-	6	8.4	7.3	0.550	-
2	Present Study (2014)	Middle Finger Length	Male	Right	7.3	9	8.17	0.390	0.043
				Left	7.3	9	8.18	0.390	0.043
			Female	Right	6.2	8.5	7.31	0.460	0.044
				Left	6.2	8.4	7.28	0.440	0.042

[20] also reported higher value as the study was conducted on Nigerians which belongs to different race groups. These differences of mean in stature between males and females are due to the fact that fusion of epiphysis of bones occurs earlier in females than in males. Males have about two more years of bone growth than females [4].

This present study was done in medical students of all India region of age group 18-22 years and the mean of stature came as 171.11 cms in males and 157.57 cm in females.

Rahul [22] studied the middle finger lengths in age groups of 16-50 yrs of Andhra pradesh population and mean in his study was 7.92 cm for males and 7.3 cms for females.

This present study was done in medical students of all India region of diffused areas of age group 18-22 years and the mean of middle finger lengths came as 8.17 cms (right side), 8.18cms (left side) in males and 7.31 cm (right side), 7.28 (left side) in females.

The table shows that the mean hand lengths of males are significantly more than the females in all the studies. Higher values also have been reported by Kaur [23] for north Indian population especially in females.

Ilayperuama [21] reported higher mean hand lengths in both genders in Srilankan population. Danborno B[20] reports higher values and his measurements of female is having less difference to male and his study group being Nigerians.

Present study shows average values of mean hand length values 16.95 cms in females but average values 18.60 cms in males in scattered random group of Indian population

In the above table, the mean values of hand breadth in the studies of Danborno B [30], Srivastava [24] and the Present one is in the nearer range suggesting that

Table 11: Hand Length

S. No	Authors	Measur-Ments	Sex	Side	Min	Max	Mean	± SD	± SE
1	Thakur[19] (1975)	Hand length	-	-	16.7	22.15	19.34	1.7	-
2	Bhatnagar[25] et al (1984)	Hand length	-	Right	-	-	19.3	1.3	-
				Left			19.42	1.6	
3	Jasuja[6] (2003)	Hand length	Male	Right	18.4	21.3	19.8	0.73	0.13
				Left	18.2	21.2	19.79	0.76	0.13
			Female	Right	19.1	19.7	17.51	0.81	0.14
				Left	19.1	19.9	17.57	0.8	0.14
4	DanbornoB[20] (2008)	Hand length	Male	Right	-	-	19.85	0.86	
				Left			19.93	0.93	
			Female	Right	-	-	18.51	0.66	
				Left			18.52	0.77	
5	Ilayperuma[21] (2009)	Hand length	Male	-	-	-	19.01	5.22	-
			Female	-	-	-	17.62	0.93	-
5	Kaur[23] et al (2013)	Hand length	Male	-	-	-	18.8	1.09	-
			Female				18.54	10.72	
6	Srivastava[24] (2014)	Hand length	Male	-	-	-	18.4	-	0.08
			Female	-	-	-	16.74	-	0.11
7	Present Study (2014)	Hand Length	Male	Right	17.3	20.4	18.6	0.74	0.081
				Left	17.3	20.4	18.63	0.76	0.084
			Female	Right	15.3	19.9	16.95	0.85	0.082
				Left	15.2	19.3	16.85	0.82	0.079

Table 12: Hand Breadth

Sr. No	Authors	Measurements	Sex	Side	Min	Max	Mean	± SD	± SE
1	DanbornoB[20] (2008)	Hand Breadth	Male	Right			8.9	0.95	-
				Left			8.68	0.92	
			Female	Right	-	-	7.82	0.49	-
				Left			7.72	0.46	
2	Srivastava[24] (2014)	Hand Breadth	Male				8.17	0.04	
			Female				7.26	0.1	
3	Present Study (2014)	Hand Breadth	Male	Right	7.79	10	8.74	0.47	0.053
				Left	7.6	9.9	8.65	0.49	0.054
			Female	Right	6.9	9	7.7	0.44	0.042
				Left	9.7	8.5	7.55	0.39	0.038

there is less difference between the hand breadths of Nigerian population studied by Danborno B [20] and the Indian one. Although still the Nigerian population the values are on higher side in both genders. All the mean values show significant sexual dimorphism, the female mean values being lower than the male values.

Conclusion

It is found that there exists a significant sexual dimorphism in male and female population. It is well predicted in hand dimensions. Males have higher values than the females in dimensions of hand and foot. The correlation of stature and middle finger length is on the higher side (p= 0.00).

In case of fragmented bodies, the multivariate regression formulas used to calculate the stature from the hand dimensions in both sexes gives a better prediction of stature than the univariate type.

This prediction values are more closer to the actual in multivariate regression formula (equi.multi.1) with correlation coefficient (r) of 0.772:

Height = 48.524 + [5.428 * (Right Hand length)] + [2.340 * (Right Hand breadth)]

In case of univariate type the following gives a good predictive value of stature than the others. (equi.uni.1)

with correlation coefficient (r) of 0.765 and (equi.uni.3) with correlation coefficient (r) of 0.720:

Height = 49.398 + [6.458 * (Right Hand length)] and

Height = 74.651 + [11.544 * (Right Middle finger length)]

The regression equations derived from present study give a better predictive value than the formulas that have been derived by other authors as evident from the correlation coefficient. These formulas can be used effectively to estimate the stature of the individual in case mutilated bodies and also can be used effectively in ergonomics such as furniture designing, machine designing and sports as well as forensic cases.

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