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Prediction of Stature from Somatometry of the Left Hand in Igbos, Nigeria

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Abstract

The identification of a person is based on some biological profiles. Stature is one of such; its prediction plays important role in forensic investigation. An attempt was made to establish the stature of the Igbos using left finger lengths, hand length and hand breadth. The correlation between stature and hand dimensions was studied. Which of the hand segments is the best to predict the stature of the Igbos? 88 males and 123 females were included in this study after obtaining informed consent. Measurements of hand segments were taken using Sliding Caliper and the height was recorded using Anthropometer. The data were subjected for statistical analysis. Significant correlation between stature and the entire hand dimensions was established except hand breadth (HB) in the females. Independent linear regression equations to calculate the stature were obtained for hand segments in both genders put together, in males and females separately. Hand length had the best prediction power in both genders put together as well as in the females. In males, the best prediction power was observed in fourth digit length followed by hand length. The multiple linear regression model generated for both genders put together performed better than the simple linear regression models for the males or females.

Keywords: Stature; Hand length; Digit length; Anthropometer; Sliding caliper

Introduction

Stature is a composite of linear dimensions of the skull, vertebral column (spine), pelvis, thigh, legs [1] and some parts of the foot [2]. It has been estimated in many populations using regression formulas derived from hand dimensions [3-17] and also from other body segments [11,18-31]. It is one of the most important anthropometric parameter for identification of an individual [1,21,29,32,33]. Estimated stature from hand length, phalangeal length as well as from inked print of the aforementioned variables has been performed [5]. Result from such study indicated no significant difference between the hand variables and the hand prints variables but revealed significant correlations between stature and the all variables.

Among the Igbos of Nigeria, much work has not been done in forensic/physical anthropology. We therefore undertake this study to generate reference data for the consumption of the scientist and the general populace using somatometry of the left hands (palmar surface).

Materials and Method

The study was based on a random sampling of 211 Subjects (females n=123, and males n=88) aged 16-45 years of the Igbo ethnic group of Nigeria, and attention was paid to stature estimation using left hand somatometry after obtaining an informed consent.

Study location and duration

The study was conducted in Imo State, Nigeria; it covered a period of ten (10) months.

Demographics

Information on age, sex, and state of origin were documented.

Exclusion criteria

Subjects who were not of Igbo origin were excluded from the study. Also subjects who were pregnant or subjects having any deformity affecting the musculoskeletal system were not allowed to participate in the study. Also hand dimension which were not significantly correlated with stature was not used to regress stature.

Anthropometrics

Stature was measured following standard protocols [34] and the following hand measurements were taken in centimeters using a sliding caliper following the procedure of [3,6,7] but on the left hand.

Stature (Y): The height was measured to the nearest 0.1cm using an Anthropometer with subjects standing without shoes with the heels held together, toes apart, and the head held in the Frankfort plane [29,34].

Hand length (HL): is the linear distance (cm) between the distal wrist crease and the distal end of the longest finger [5,29] (Figure 1).

Hand breath (HB): is the linear distance between the middle projecting part of the thumb in adducted position and the corresponding part of the ulna side of the hand [12,15] (Figure 2).

- 1st digit length (1st DL) is the linear distance (cm) between the proximal digital crease and the distal end of the first finger.
- 2nd digit length (2nd DL) is the linear distance (cm) between the proximal digital crease and the distal end of the second finger.
- 3rd digit length (3rd DL) is the linear distance (cm) between

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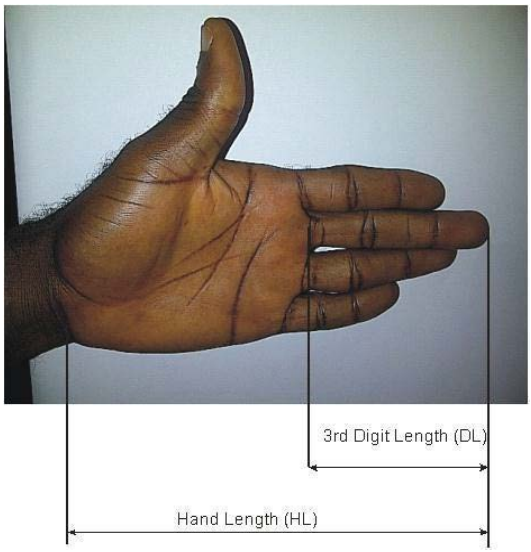

Figure 1: Shows the segmental landmarks for Hand length (HL), and 3rd digit length (3rd DL).

Figure 2: Shows the segmental landmarks for the Hand breath (HB).

the proximal digital crease and the distal end of the third finger see Figure 1.

- 4th digit length (4th DL) is the linear distance (cm) between the proximal digital crease and the distal end of the fourth finger.
- 5th digit length (5th DL) is the linear distance (cm) between the proximal digital crease and the distal end of the fifth finger.

Data Presentation and Analysis

The data analysis was carried out using statistical package for social sciences (SPSS 17.0 software). In summarizing the data, the Minimum, Maximum, Mean and Standard deviations were estimated and presented. A comparison of difference of variable in females and males left hand dimensions was performed. Pearson correlation was then applied to test the relationship between stature and hand dimensions and the results are presented for both genders together, males and females.

The prediction function was derived through linear regression for each of the measurement with stature for both genders together, males and females separately. The presentation also provides the values of Constant, Regression coefficient, Percentage variation explained (R_2) and Significance of regression coefficient. The multiple linear regression models [26] with the explanatory variables or repressors'- left hand dimensions were proposed as a statistical model to explain the total variation. The generated regression formula from a stepwise analysis is such that stature (y)=a (constant)+b_1 (regression coefficient for the first variable) x_1 (first variable)+b_2 (regression coefficient for the second variable) x_2 (second variable)+…… b_n (regression coefficient for the nth variable) xn (nth variable), with this we can estimate stature from hand dimensions. In the results that follow, R indicates the multiple correlation coefficient value [28]. It is one of the measures used for model adequacy. It is the correlation between the observed values and the fitted values for the dependent variable. R_2 explains the percentage that a dimension contributes to the variation in the dependent variable (stature). R_2adjusted is used to compare the regression models containing different number of explanatory variables (hand segments). The standard error of estimate (SEE) is the error that may arise from estimating stature. It predicts the deviation of estimated stature from the actual stature [27]. A low value of SEE is indicative of the greater reliability of prediction from a particular measurement while a higher value denotes less reliability.

Result

We can see the standard deviation, the mean, the maximum and minimum values of the anthropometric variables in both genders put together (Table 1). Overall, males are more varied with higher mean values than females. All the anthropometric dimensions measured directly showed statistically significant differences between females and males: HL, HB and 1st DL ($p<0.0001$), 2nd DL and 5th DL ($p<0.002$), 3rd DL ($p<0.001$), with males having a higher mean value than females (Table 2).

The correlation coefficient between stature and the left hand dimensions in both genders put together, females and males respectively was found to be statistically significant and positive, indicating a strong relationship between stature and left hand dimensions, except for hand breadth (HB) in females. The highest positive correlation was observed in hand length (HL), r=0.727 while the least was observe in 5th digit length (5th DL) r=0.504 in both genders put together (Table 3). For the females, the least significant correlation was observed in the 5th DL, r=0.397 while the highest value was obtained in HL, r=0 .638. In the male population, the least significant correlation was observed in HB, r=0.431 while the highest was observed in 4th DL, r=0.633. The Constant, Regression coefficient and Variation explained (R^2) derived for each of the left hand measurements with stature are shown in Table 4 for both genders put together, and in Table 5 for females and males respectively. The regression coefficients were significant indicating that they are contributing for the prediction of stature. The variation explained (R^2 x 100) showed that it ranges from 25.4% to 52.8 % in both genders. For the females the variation explained ranged from 15.8% to 40.7%. In the males, the variation explained ranged from 18.6% to 40.1%.

Table 6 shows the values for R, R_2, Adjusted R_2, and SEE of the left hand variables in both genders put together, females and males respectively. In both genders together, one multiple linear regression models was constructed using 1st DL and 2nd DL and this has the highest values for the coefficient of determination R_2 as 0.505, R_2 Adjusted as 0.495 and multiple correlation coefficient R as 0.711 with a lower SEE as 6.158. Seven simple linear regression models were also constructed. The best simple linear regression model was developed using HL and this

Variables	Both gender					Females					Males				
	N	Min	Max	Mean	SD		N	Min	Max	Mean	N	Min	Max	Mean	SD
AGE	211	16	45	23.58	4.95	123	16.00	45	23.74	5.36	88	18	43	23.35	4.34
STATURE	211	149	190	167.55	9.1	123	149.00	190	163.17	7.64	88	156	190	173.66	7.3
HL	92	16.4	22	19.24	1.18	55	17.4	21	18.77	0.85	37	16.4	22	19.92	1.27
HB	93	6.1	11.2	9.43	0.82	56	6.10	10.8	9.03	0.71	37	8.3	11.2	10.04	0.6
1ST DL	96	5.1	8.4	6.49	0.62	56	5.10	8.4	6.27	0.52	40	5.2	7.8	6.81	0.61
2ND DL	96	5.7	9.2	7.18	0.57	56	5.80	8.15	6.98	0.43	40	5.7	9.2	7.46	0.63
3RD DL	95	6.1	9.9	7.97	0.64	56	6.60	9.2	7.77	0.49	39	6.1	9.9	8.25	0.73
4TH DL	96	5.2	9.3	7.39	0.59	56	6.40	8.45	7.2	0.43	40	5.2	9.3	7.65	0.69
5TH DL	96	3.7	7.54	5.9	0.59	56	4.60	7.54	5.77	0.48	40	3.7	7.5	6.08	0.69
HL: Hand Length; HB: Hand Breath; DL: Digit Length															

Table 1: Descriptive statistics of age (years), left hand dimensions (CM) of both genders, females and males.

Variables	Paired Differences					Df	T	Sig. (2-tailed)
				5% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
HL (F)-HL (M)	-1.550	1.186	0.297	-	-0.918	-5.228	15	0.000
HB (F)-HB (M)	-1.187	0.7549	0.195	-	-0.769	-6.088	14	0.000
1st DL (F)-1st DL (M)	-0.681	0.526	0.124	-0.942	-0.419	-5.488	17	0.000
2nd DL (F)-2nd DL (M)	-0.467	0.557	0.132	-0.745	-0.189	-3.544	17	0.002
3rd DL (F)-3rd DL(M)	-0.678	0.646	0.157	-	-0.346	-4.326	16	0.001
4th DL (F)-4th DL (M)	-0.536	0.506	0.119	-0.788	-0.285	-4.500	17	0.000
5th DL(F)-5th DL (M)	-0.418	0.493	0.116	-0.664	-0.174	-3.603	17	0.002

Table 2: Comparison of difference of variable in females and males of left hand dimensions.

Variables	Both gender			Females			Males		
	N	Min	Max	N	Pearson Correlation	Sig. (2-tailed)	N	Pearson Correlation	Sig. (2-tailed)
HL	211	16	45	55	0.638**	0	37	0.610**	0
HB	211	149	190	56	0.166	0.223	37	0.431**	0.008
1ST DL	92	16.4	22	56	0.409**	0.002	40	0.528**	0
2ND DL	93	6.1	11.2	56	0.465**	0	40	0.594**	0
3RD DL	96	5.1	8.4	56	0.482**	0	39	0.570**	0
4TH DL	96	5.7	9.2	56	0.472**	0	40	0.633**	0
5TH DL	95	6.1	9.9	56	0.397**	0.002	40	0.511**	0.001
HL: Hand Length; HB: Hand Breath; DL: Digit Length									

Table 3: Pearson correlation between stature with left hand dimensions in both genders put together, females and males. Correlation is significant at the 0.01 level (2-tailed) ** Correlation is significant at the 0.05 level (2-tailed)*.

Variables	Constant	Regression Coefficient	R^2	p value
HL	66.603	5.161	0.528	0.000
HB	111.841	5.733	0.324	0.000
1st DL	110.952	8.530	0.370	0.000
2nd DL	96.304	9.761	0.414	0.000
3rd DL	99.744	8.353	0.374	0.000
4th DL	97.296	9.347	0.409	0.000
5th DL	122.590	7.414	0.254	0.000
1st DL	85.207	5.089	0.505	0.000
2nd DL		6.702		0.000
HL: Hand Length, HB: Hand Breath, DL: Digit Length				

Table 4: Constant, Regression coefficient and Variation explained (R^2) of left hand variables with Stature (dependent) variables in both genders.

Variables	Constant	Females Regression Coefficient	R^2	p-value	Constant	Males Regression Coefficient	R^2	p-value
HL	87.312	3.935	0.407	0	103.922	3.46	0.372	0
HB					120.681	5.201	0.186	0.008
1st DL	135.252	4.154	0.167	0.002	129.577	6.438	0.279	0
2nd DL	121.164	5.752	0.216	0	121.355	6.985	0.353	0
3rd DL	121.149	5.168	0.232	0	124.544	5.927	0.325	0
4th DL	119.815	5.759	0.223	0	121.017	6.854	0.401	0
5th DL	135.865	4.404	0.158	0.002	139.546	3.801	0.261	0.001
HL: Hand Length, HB: Hand Breath, DL: Digit Length								

Table 5: Constant, regression coefficient and variation explained (R2) of left Hand variables with stature (dependent) variable in females and males.

Variables	Both genders				Females				Males			
	R	R^2	Adjusted R^2	SEE	R	R^2	Adjusted R^2	SEE	R	R^2	Adjusted R^2	SEE
HL	0.727	0.528	0.523	5.782	0.638	0.407	0.396	4.072	0.610	0.372	0.354	5.794
HB	0.569	0.324	0.317	6.895					0.431	0.186	0.162	6.623
1st DL	0.608	0.370	0.364	6.911	0.409	0.167	0.152	4.845	0.528	0.279	0.260	6.416
2nd DL	0.644	0.414	0.408	6.666	0.465	0.216	0.201	4.702	0.594	0.353	0.336	6.076
3rd DL	0.617	0.380	0.374	6.876	0.482	0.232	0.218	4.654	0.570	0.325	0.307	6.288
4th DL	0.639	0.409	0.402	6.697	0.472	0.223	0.208	4.682	0.633	0.401	0.385	5.848
5th DL	0.504	0.254	0.246	7.523	0.397	0.158	0.142	4.873	0.511	0.261	0.242	6.492
1st DL 2nd DL	0.711	0.505	0.495	6.158								
HL: Hand Length, HB: Hand Breath, DL: Digit Length												

Table 6: R, R^2, Adjusted R^2, and SEE of left variables in both genders, females and males.

has the highest values for the coefficient of determination R_2 as 0.528, R_2 Adjusted as 0.523 and multiple correlation coefficient R as 0.727 with 5.782 as the SEE.

In the females, no multiple linear regression model was developed but the best simple linear regression model was developed using HL and this has highest values for the coefficient of determination as R_2 0.407, R_2 Adjusted as 0.396 and multiple correlation coefficient R as 0.638 with a 4.072 SEE. In the males, it was not possible to develop multiple linear regression models. The best simple linear regression model was developed using 4th DL. This very model has the coefficient of determination R_2 as 0.401; R_2 adjusted as 0.385 and multiple correlation coefficient R as 0.633 with 5.848 SEE. The best simple linear regression equation developed for both genders together, females and males respectively are: stature both gender=66.603+5.161(HL), stature female=87.312+3.935 (HL) and stature male=121.017+6.854 (4th DL) i.e. when the explanatory variables were considered one after the other putting the value of R into consideration. Stature also could be estimated using other dimension of the left hand; the regression equations generated are in Tables 7 and 8.

The maximum, minimum and the mean predicted values of stature through the regression function were similar to the maximum, minimum and mean observed values (Table 9). In females, the mean predicted value and the maximum predicted value underestimate the mean and the maximum observed values while the minimum predicted value overestimates the minimum observe values and these values were not significant. In the males the mean predicted values were similar to the mean observed value (Table 10).

Discussion

The results of the present study clearly indicate that stature can successfully be estimated from the somatometry of the left hand in condition where forensic experts are confronted with mutilated upper extremity segments or body part. Such information gotten can supplement the three (age, sex and race) of the "Big Four" of Forensic Anthropology.

The findings of this investigation also indicate that all the hand dimensions are positively and significantly corrected with stature except HB in females. This observation has the implication that HB cannot be used to estimate stature in Igbo females except when both sexes are put together. HL shows stronger correlation with stature than those of other hand dimensions. This observation is confirmed by lower SEE as well as high value of R, R_2, and Adjusted R_2 for HL. It means that the regression equation generated using HL in both genders together and females give high degree of reliability and accuracy than those of other hand dimensions. In males reliability and accuracy was highest using 4th DL.

The present study also shows that the multiple linear regression equation obtained using 1st DL and 2nd DL in both genders performed better than the simple linear regressions generated for the male or females. This statement is also proved by the values of R, R_2, and Adjusted R_2, i.e. (0.711, 0.505, and 4.95) respectively, see Table 6.

Over the decade, close relationships between stature and dimensions of various body segments have been reported and the results are frequently applied in anthropometric studies and medico-legal investigations [1,2,4,7,19,33] the application of such result must be population specific since genetics, environment and even nutrition influences stature [12,35,36], and this is in agreement with the present study [3]. Studied subjects in Delhi and found accurate or near accurate correlation between stature and length of fingers. They used independent linear regression equations and suggested that results are statistically significant. From their data it is evident that the index finger is best for the prediction of stature. In this present study, the 2nd digit length was the best to estimate stature in both gender together while the 3rd and 4th digit lengths was the best to predict stature respectively

Regression equation Both Genders	±SEE
Stature=66.603+5.161(HL)	5.78192
Stature=111.841+5.733(HB)	6.89491
Stature=110.952+8.530(1ST DL)	6.91076
Stature=96.304+9.761(2ND DL)	6.66582
Stature=99.744+8.353(3RD DL)	6.87608
Stature=97.296+9.347(4TH DL)	6.69735
Stature=122.590+7.414(5TH DL)	7.52301
Stature=85.207+5.089(1ST DL)+6.702(2ND DL)	6.15842
HL: Hand Length, HB: Hand Breath, DL: Digit Length	

Table 7: Regression Equations for estimation of Stature in both genders using left dimensions.

Regression equation Females	±SEE	Regression equation Males	±SEE
Stature=87.312+3.935(HL)	4.072	Stature=103.922+3.460(HL)	5.794
Stature=135.252+4.154(1ST DL)	4.845	Stature=120.681+5.201(HB)	6.623
Stature=121.164+5.752(2ND DL)	4.702	Stature=129.577+6.438(1ST DL)	6.416
Stature=121.149+5.168(3RD DL)	4.654	Stature=121.355+6.985(2ND DL)	6.077
Stature=119.815+5.759(4TH DL)	4.682	Stature=124.544+5.927(3RD DL)	6.288
Stature=135.865+4.404(5TH DL)	4.873	Stature=121.017+6.854(4TH DL)	5.848
		Stature=139.546+3.801(5TH DL)	6.492
HL: Hand Length, HB: Hand Breath, DL: Digit Length			

Table 8: Regression Equations for estimation of Stature in females and males using left hand dimensions.

Observed Value		Minimum	Maximum	Mean	Std. Deviation	N
Value	HL	149.00	190.00	167.55	9.10	211
	HB	151.25	180.15	165.88	6.10	92
Predicted Value For:	1st DL	146.82	176.06	165.90	4.75	93
	2nd DL	154.46	182.61	166.35	5.27	96
	3rd DL	151.94	186.11	166.35	5.58	96
	4th DL	150.69	182.43	166.29	5.36	95
	5th DL	145.90	184.23	166.35	5.54	96
	1st DL 2nd DL	150.03	178.49	166.35	4.36	96
HL: Hand Length, HB: Hand Breath, DL: Digit Length						

Table 9: Minimum, Maximum, Mean and standard deviations of the predicted Values of stature by regression functions with left hand variables in both genders.

Observed Value		Females					Males				
		Mini	Max	Mean	SD	N	Min	Max	Mean	SD	N
	HL	149.00	190.00	163.17	7.64	123	156.00	190.00	173.66	7.30	88
	HB	155.78	169.94	161.17	3.34	55	160.67	180.05	172.87	4.39	37
	1st DL						163.85	178.93	172.88	3.12	37
	2nd DL	156.44	170.15	161.29	2.15	56	163.05	179.79	173.43	3.94	40
	3rd DL	154.52	168.04	161.29	2.45	56	161.17	185.61	173.43	4.43	40
	4th DL	155.26	168.69	161.29	2.53	56	160.70	183.22	173.46	4.30	39
	5th DL	156.67	168.48	161.29	2.48	56	156.66	184.76	173.43	4.72	40
		156.12	169.07	161.29	2.09	56	160.16	181.32	173.43	3.81	40
HL: Hand Length, HB: Hand Breath, DL: Digit Length											

Table 10: Minimum, Maximum, Mean and standard deviations of the predicted Values of stature by regression functions with left hand variables in females and males.

in females and males because of the values of R and SEE [37-40]. Reported for Japanese women a correlation (r) of proximal phalange and stature ranging from 0.521 to 0.696. The regression formulae possessed standard errors ranging from 3.59 to 4.27cm. In this study, the correlation of the female's digit lengths with stature ranged from 0.397 to 0.638 while the regression formula possessed SEE ranging from 4.702 to 4.873cm. Although our dimensions for digit lengths incorporated both the distal, middle and part of the proximal phalanx; the upper limits of these values (r, and SEE) are comparable with the study above.

Studies [4,5,7,8,37] have estimated stature from hand length and phalange length and also reported sexual dimorphism in mean hand length. Regression equations were generated. The mean stature in the males was higher as compared to that of the females in such studies.

These findings are congruent with that of this study. Comparing this study with the same isolated genetic population in our previous study using right hand dimensions [2], we observed that the values of R for the various left hand dimensions used to test model adequacy were higher in this present study. Also this study indicated lower SEE than that of our previous study. This means that left hand dimensions are more adequate to estimate stature in the same population than the right hand dimensions.

Conclusion

The best dimension to predict stature from the left hand somatometry of the study population is hand length followed by 1st and 2nd digit lengths. Also hand length provides the precise means of estimating stature in the females, this is followed by 3rd digit length. In males, 4th digit length is the best followed by hand length. The regression formula generated in this study will be of utmost help to Anatomists, Anthropologist, Archaeologist and Forensic experts.

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